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ATYPICAL NESTING HABITAT OF THE PEREGRINE FALCON (*Falco peregrinus*) IN VICTORIA, AUSTRALIA

CLAYTON M. WHITE, WILLIAM B. EMISON AND WILLIAM M. BREN

ABSTRACT.—Nesting of the Peregrine Falcon (*Falco peregrinus*) in disused stone quarries is not unusual, but occupancy of actively worked quarries represents a departure from typical nesting behavior. In Victoria, Australia, seven of 11 stone quarries occupied were actively working quarries. In one case the eyrie was 50 m from quarrying operations, rock crushing equipment and machinery. In 1982 Peregrines occupied a hydroelectric dam within 3 yrs of its completion. They also occupied a gravel loading silo in use and nested about 20 m above a truck loading area. Such exploitation of seemingly “unsuitable” or “disturbed” sites could be expected in an expanding Peregrine population containing a high percentage of younger inexperienced adults. In Victoria the population is stable and some quarries have been occupied in excess of 20 yrs. We suggest such quarry use in Australia reflects a large, numerically healthy falcon population with a large vulnerable food supply in areas otherwise limited in natural nesting sites.

The Peregrine Falcon (*Falco peregrinus*) can and does naturally nest in close proximity to human activity (i.e. urban building, bridges, etc.). Such situations depart from the normally isolated and remote cliff sites characteristic of the species (Hickey 1969). Indeed, with the reintroduction of the Peregrine in the eastern United States, use of bridges has become frequent (Cade and Dague 1985). Overall, however, such nestings are uncommon. One of the more commonly used man-made structures is the stone quarry and in fact it should be, as a quarry is nothing other than a man-made cliff or rock face. Many quarries provide new nesting habitat in regions where otherwise no nesting substratum exists and most quarry use is of disused quarries. Fischer (1973) indicated that disused quarries along the Main, Necker and Weser rivers in the Unstrut Valley, Germany, opened up an entirely new area for nesting. Likewise, Ratcliffe (1980) documented that many quarries in Britain provide new crags for nesting in regions where none otherwise existed. We suggest that quarry use in Victoria functioned in the same fashion and is related to food supply.

We currently know of 11 quarry eyries among more than 79 natural cliff sites studied (see Pruett-Jones et al. 1981; White et al. 1981). Of these 11 quarries, seven are being excavated continuously.

Herein, we describe five of these sites. The structure of worked quarries was similar in all regards to those in disuse.

METHODS

Studies on Peregrines in Victoria (ca. 227 300 km²) started in 1975, continued through 1984, and thereafter occurred as opportunity presented (see Emison et al. 1988). No attempt was made to examine intensively all known stone quarries in Victoria. Rather, disused quarries were examined as they were found or reported; working quarries were examined when a report of falcons was received at the Arthur Rylah Institute (Victoria has an extensive bird watching community; between 1977 and 1981 nearly 800 observers reported data and the Peregrine research program received attention in the public media). Each quarry examined was visited on foot and frequently the “high walls” were climbed. Absence of suitable nesting ledges was usually noted. Measurements of prey density were not made in a systematic manner, but impressions of prey density near eyries were casually noted. Comparisons between Peregrine distribution and the distribution of four major prey groups (Rock Dove [*Columba livia*], Galah [*Cacatua roseicapilla*], rosellas [*Platycercus* sp.], and European Starling [*Sturnus vulgaris*]) were made using the Atlas of Victoria Birds (Emison et al. 1987). For the Atlas the state was divided into blocks of 10 min (ca. 18 km) of E. Lat. by 10 min (ca. 15 km) of S. Long. of area, resulting in 918 blocks in Victoria. Bird species occurrence was recorded for each block during the Atlas period (1973-1986) which gave distribution and an index of frequency.



Figure 1. Site number 1—panoramic view of quarry. Note gravel loader in left center of photo; arrow indicates eyrie location.

RESULTS

The Eyries. The only thing most quarry eyries had in common was their placement on high walls. Each site had particular features of interest and it is instructive to describe a sample to present a clear picture of the variables at these sites.

a) Site #1 is in the largest active stone quarry in Victoria (ca. 80 ha) (Fig. 1). The quarry started operation in 1929 and Peregrines began nesting there at least in the early 1960s (Max Parker, pers. comm.). Pairs have used five or six different walls depending on where quarrying occurred but normally selected less disturbed areas. Falcons were so accustomed to quarrying operation that on one occasion we saw a Peregrine chase a Feral Pigeon past the office building and toward a 10 m high gravel loader in operation filling vehicles. The pigeon flew into dust generated by the loader and seemed to slam with total abandon into the loader and fell to the ground be-

tween two vehicles. The Peregrine landed on the roof of the vibrating loader amidst rising dust. Unable to locate the pigeon, the falcon left within about one min but at no time seemed disturbed by the commotion.

b) Site #2 is a very small, active quarry (30 × 75 m) in the shape of a quarter circle. While we do not have a history of falcon use of the site, in 1977 and 1978 nesting occurred about 50 m from a section of the quarry being worked (Fig. 2).

c) Site #3 is about the same dimensions as #2 but more U-shaped and located about 12 km in a straight line from #2. We have no history of use of the quarry. The quarry is inactive and serves as a firing range on weekends for a local rifle and pistol club. In 1977 a Peregrine eyrie was located opposite and at a 90° angle from the targets and about 60 m from bench rests and the area housing shooters. On 29 October 1977 we were at the site when shooting started at 1300 H. The female left her perch beside



Figure 2. Site number 2—arrow indicates eyrie location. Work is being done about 50 m to the left of the eyrie.

a single $3\frac{1}{2}$ wk old nestling when shooting started, screamed a few times and perched in a tree about 100 m away. She remained perched until the shooting was over. We were told by locals that the female laid eggs and started incubation after weekend shooting had already started.

d) Site #4 is dug as a long, shallow pit into otherwise level ground (Fig. 3) rather than into a hillside as with most quarries. Vertical faces of high walls are about 15 m high and face each other about 150 m apart. The long axis is about 350 m. The eyrie was actually below the level of surrounding land. As desired rock was removed, the quarry was filled in at one end and new ground was opened at the other end. The quarry was in essence moving in one direction. Filled areas were then reclaimed and replanted. As new high walls were created, the falcons moved and the actual wall used for nesting seemed to depend upon which one was being mined during egg laying. The wall used in 1978 was opened

in 1976 (Peter Shanahan, pers. comm.). The quarry represented the only vertical rock faces within a 13 km radius, and the closest rock face is another quarry in the city of Geelong. Workmen frequently watched the pair cooperatively hunting above the quarry pursuing flocks of Feral Pigeons (about 15–30 individuals) or Common Starling flocks of ≥ 100 individuals (John Russell, pers. comm.). Although four young fledged in 1977 (four young is an unusually high number of young in Victoria), success of the pair was apparently not good because of the open and unsheltered nature of nesting ledges. In 1978 water gathered on the nesting ledge and eggs were in a pool of mud when checked. The pair may have been younger adults as the quarry had been used <5 yrs by Peregrines in 1978.

In 1986 and 1987 a pair of Peregrines fledged young from a nest on top of a 30 m gravel loading silo (Fig. 4) located at this quarry. The silo had a covered conveyor belt housing that, because of its



Figure 3. Site number 4—panoramic view of quarry. Arrow indicates eyrie location.

position, left a gap of about 0.3 m high covering 6 m². This platform, 20 m above the trucks, provided a nest scrape made in powdery dust from years of operation.

e) Site #5 has one main face of limestone 150 m long and 35 m high with only one suitable nesting ledge, a cut about 25 m from the ground. This ledge was used for at least 20 yrs (Neville Holland, pers. comm.) and during 8 yrs of monitoring by us, 17 young fledged. The quarry has been continuously worked and the eyrie was only 50 m from heavy machinery and a rock crusher. The falcons showed no concern as long as humans did not approach the eyrie too closely in a direct manner.

f) **Dam Site.** Like quarries, dams form cliff-like structures that have been used by nesting falcons. In Zambia, for example, where the Peregrine is a scarce breeder at best, nesting has occurred on a buttress of the Kariba Dam wall (Osborne and Colebrook-Robjent 1980). A dam 35 km from Melbourne was completed in 1979. The front wall of the dam rises about 95 m high at the highest point, whereas the back of the dam wall rose about 10 m above the water's surface during years of average rainfall. Peregrines nested on the back wall in 1982. A "draw-off" structure protruded over the water surface and

where the structure met the dam wall proper a conical "pot-hole" of 1.3 m³ was formed that provided the nesting ledge. The eyrie was within 20 m of a service road and car park used by reservoir staff. A service walkway along the "draw-off" structure passed directly over top of the eyrie and within 0.6 m. While this site was only successful in raising two young in 1982, there were signs of falcon presence at the dam in subsequent years.

Assessment of Prey. While we have no direct measure of prey density or vulnerability we have attempted to derive an index based on species occurrence. The four major bird prey groups made up, on average, 62% (of 65 species) of prey. Pigeons were found in 72% (av.) of the Peregrine eyries, Galahs in 54%, rosellas in 29%, and starlings in 65% (see Pruett-Jones et al. 1981). Of the 84 blocks in which Peregrines were recorded breeding in the Atlas period (Emison et al. 1987), starlings and Galahs occurred in 82 (the block in which either species did not occur was different), rosellas in 74, and while pigeons were not seen in about 15 blocks where Peregrines bred they nonetheless were found in eyries as food. Domestic pigeons are released by the thousands in racing contests and thus occur throughout Victoria during these races. Lost pigeons from

these races are seen in unlikely places nearly any time of the year.

As an indication of distribution (commonness?) of these major prey species Galahs were seen in about 84% of the blocks within Victoria and were present in about 50% of the state in any given month except February. Starlings were seen in about 91% of the blocks and present in over 60% of the state in any given month. The most widespread bird in Victoria, by comparison, is the Australian Magpie (*Gymnorhina tibicen*) reported in about 98% of the blocks within nearly 85% of the state in any given month. By contrast, two raptors, the Peregrine and the relatively widespread and abundant Australian Kestrel (*Falco cenchroides*), have values that are 38% and 83% of the blocks and about 5% and 35% of Victoria in any given month, respectively.

As a relative index of density, Galahs are reported on 48% of the bird lists in blocks where they occur. Comparative values are 60% of lists for the starlings and 7% of lists for the Peregrines. The proportion of Galahs to starlings in reporting rates was the same as the proportion found as prey in eyries.

DISCUSSION

In regions of high Peregrine population pressure younger breeding members, usually part of the "floating population," may use nest sites that older established pairs would not. In Britain where there are currently about 1100 pairs in the 229 900 km² region, about 25 disused quarries have been used and 11 of these are in areas where no other suitable cliffs exist (Ratcliffe 1980). However, in 1979 in a departure from the occupancy of disused quarries, one British eyrie was in an unused portion of a quarry where work was underway and a second eyrie was above an excavation site in progress (Ratcliffe 1980). Similarly, in the German Democratic Republic, where the Peregrine population is currently (1986) in a rapid recolonization phase, an actively worked quarry was recently occupied by nesting Peregrines (H. Richter, via D. J. Brimm, pers. comm.). We also know of a site in Alaska where in 1980 a presumably younger pair of adults successfully nested on a cliff so near a road construction site that concussion of dynamite blasting was seen to ruffle feathers on the perched male. The falcons moved onto the cliff, that over the past 30 yrs had only been used by the Golden Eagle (*Aquila chrysaetos*), after construction had already started (D. Roseneau, pers. comm.). We presume the Peregrines



Figure 4. Gravel loading silo site—arrow indicates eyrie location on silo.

were first-time nesters from the "floater" population as the nearest known historical sites more than 20 km away were also occupied.

Expansion of Peregrines into new situations and their use of more "unorthodox" nesting sites is seemingly related to, among other things, an abundant food supply that can be adequately exploited. Ratcliffe (1980) did not have a direct measure of the food base but suggested that the expansion of Peregrines in Britain into new areas and their use of cliffs for nesting heretofore unoccupied by falcons was a function of the combination of an expanding population (many young entering into the adult cohort so density dependent) and abundant food supplies (so density independent with domestic pigeons as a dominant part of that food supply). Nelson and Myres (1976) suggested that the reverse also happens and interpreted the reduction of Peregrines in the Queen Charlotte Islands, Canada, to be a function, in part, of reduced prey. Certainly the

reintroduction of Peregrines back into North America has been as successful as it has by initially selecting sites with abundant food supplies nearby (e.g., erecting towers in marshes).

Like European quarries at least two of those we have discussed (Site 1 and Site 4) provide new habitat in regions where no other naturally occurring rock faces exist within 15–20 km. The rapid occupancy by Peregrines of recently exposed rock faces at some quarries in Victoria suggests that a large population of “floating,” non-breeding birds is present. Of further interest is that quarries in general, and quarries in active operation especially, became occupied while other areas of Victoria with seemingly excellent natural rock faces were unused. This suggested that not only was there a numerically healthy surplus population of Peregrines available to exploit these quarters but that those quarries occupied were in areas of a high food base that helped to override the negative effect of disturbance and thus provided the proper set of conditions consisting of an essential balance between nesting and foraging habitat. In essence quarries provided something that nesting on natural cliffs did not (we have several examples of eggs being laid annually and subsequently broken because no adequate ledges exist on particular cliffs). Rapid occupancy of the dam site once it was completed corroborates this notion. We suggest that the Peregrine population in Victoria may be near saturation and that unoccupied natural cliffs in areas distant from the nearest used eyrie have some biotic deficiency such as lack of a nearby exploitable food supply. We are not yet able to explain why all seemingly optimal environments are not exploited at the same frequency. For example, Peregrines do not nest in cities in Victoria where there is an abundance of nesting locations and an enormous food supply, especially Feral Pigeons. This becomes even more of an enigma because where cliffs or quarries are not available, Peregrines in Victoria use trees for nest sites (see White et al. 1981). We were interested in the fact that of the data presented by Ratcliffe (1980) about 2.5% of the eyries in Britain were in quarries, while in Victoria nearly 14% were in quarries. Having seen many sub-optimal eyries in Britain, we wonder why more quarries there are not used. Use of quarries in Victoria becomes more interesting when one realizes that Britain and Victoria have similar land area, but about 10 times more cliff eyries are known in Britain than in Victoria. We are impressed

by the fact that more than half of the quarries used by Peregrines in Victoria are in continual operation.

The fact that a few disused quarries in Victoria with seemingly adequate ledges and food supply nearby are unoccupied by falcons while some in operation are used is also something that we are not fully able to explain. However, we can suggest that at least the following conditions may be responsible. 1) Local food supplies may be efficiently exploited only from certain quarries. 2) Peregrine population pressure is such that what we would categorize as “marginal” habitat (in the sense that disturbances are frequent and severe) becomes used in spite of less desirable conditions because an abundant food supply more than compensates for the disturbance factor. 3) There is some association of biotic and abiotic factors in concert at quarries that we have not been able to identify. 4) Falcons that occupy such sites are more tolerant of disturbances than the norm of the species. If the latter is the case it would be interesting to determine if such tolerance is a heritable factor or learned because of previous experiences early in their lives.

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The 1987 Annual Meeting of The Raptor Research Foundation, Inc.—More than 400 were in attendance at the 21st annual meeting of The Raptor Research Foundation, Inc., held on 28–31 October 1987 in Boise, Idaho. The scientific program included 74 paper presentations and 18 poster presentations. Gary Duke was elected as the Foundation's new President, succeeding Jeffrey L. Lincer, while Richard J. Clark, James E. Fraser and Jim Fitzpatrick will continue as Vice President, Secretary, and Treasurer, respectively. Newly elected directors included Bernd Meyburg, Keith Bildstein, and Jeffrey L. Lincer. Thomas Hamer of Western Washington University was presented with the William C. Andersen Memorial Award for 1987 for the best student paper presentation. The paper was co-authored by Fred Samson. The Leslie H. Brown Memorial Award for 1987 was presented to Geoff and Hilary Welch for their raptor research and conservation efforts in Djibouti. The Stephen R. Tully Grant for 1987 was awarded to Kelly F. Hogan for a study of Prairie Falcon foraging ecology in the Chihuahuan Desert. The 22nd annual meeting of the Foundation will be held on 26–29 October 1988 at the Crowne Plaza Holiday Inn Metrodome in Minneapolis, Minnesota.

TROPHIC STRUCTURE OF SOME NEARCTIC, NEOTROPICAL AND PALEARCTIC OWL ASSEMBLAGES: POTENTIAL ROLES OF DIET OPPORTUNISM, INTERSPECIFIC INTERFERENCE AND RESOURCE DEPRESSION

FABIAN M. JAKSIĆ

ABSTRACT.—Trophic structure (i.e., food-niche relationships) of owls at levels of resolution ranging from entire predator assemblages to local populations were scrutinized. Results indicate that trophic structure changes geographically, that potentially competing owls vary in number and identity, and that owl trophic guilds usually include hawks and sometimes other carnivores. Analysis of trophic ecology of local populations of *Athene*, *Tyto* and *Bubo* owls living in Chile, Spain, California, and Colorado shows that diet breadths and mean prey sizes differ widely and inconsistently across regions. Apparently, varying characteristics of trophic structure emerge from opportunistic behavior of local owl populations with regard to profiles of prey size and abundance. Competition for food resources (when it occurs) may be more likely effected via resource depression rather than resource depletion, and the primary mechanism may be interference rather than exploitation.

Community ecology can be considered a shorthand term for studying the use sympatric organisms make of three major niche axes: habitat, time and food (Schoener 1974; Giller 1984). In the recent past segregation of sympatric species along niche axes was thought to be aimed at reducing exploitation competition by allowing potential competitors to gain access to different and exclusive food resources (MacArthur 1972; Cody 1974; Pianka 1983).

Community ecology studies on owls are still in their infancy (see Clark et al. 1978; Jaksic 1985). Probably because owl food habits are easier to study than habitat selection or activity time, most community-oriented studies have dealt with trophic structure (i.e., food-niche relationships) of sympatric owls. Considering those studies that deal with at least three sympatric species (the minimum number that I think qualifies as an assemblage of owls), an early, pioneering stage can be recognized between 1930–1970 (e.g., Cahn and Kemp 1930; Errington 1932; Wilson 1938; Uttendorfer 1939; Kirkpatrick and Conway 1947; Hagen 1952; Craighead and Craighead 1956; Weller et al. 1963; Ross 1969). During this stage, quantifications of prey consumed by sympatric owls were interpreted qualitatively without recourse to summary indices or statistical testing, and general conclusions were drawn with emphasis on “the balance of nature.”

A second stage began in the 1970s when the first modern ecological treatment of an owl assemblage was published by Marti (1974), followed by those of Herrera and Hiraldo (1976), Lundberg (1979),

Jaksic (1983), Mikkola (1983), Yalden (1985), and Korpimäki (1986b, 1987a), among others. The sophistication of quantitative and statistical testing of trophic relationships of sympatric owls varied but usually emphasized measures of diet similarity in light of competition theory, particularly those aspects bearing upon niche segregation, species packing and limiting similarity.

Despite increased quantification and regard for theory testing, little is known about the trophic structure of owl assemblages. A recurring theme, however, is that trade-offs between habitat and diet alleviate interspecific competition (e.g., Yalden 1985, following the tradition started by Lack 1946). Although sympatric owl species (e.g., those inhabiting the same forest) may differ in the use of different habitat categories (i.e., they may be allotopic, some in forest cores, others in forest gaps), it has yet to be shown that partitioning of the habitat axis actually leads to a reduction of overlap in use of prey resources (see Nilsson 1984, for the opposite finding). Exploitation competition is clearly not reduced if allotopic owls use the same habitat-generalist prey population. Regardless whether a prey population is used by different owl species in a forest patch or in an adjacent meadow, owl species may still be exploiting the same prey resource and competition may not be alleviated. The same applies to temporal segregation. Regardless whether a prey population is being exploited temporally by different owl species, the prey resource may still be one and the same (see Jaksic 1982; R. L. Knight, pers. comm., disagrees).

Although many factors may impinge upon the ecology of particular owl species (e.g., nest-site availability, Lundberg 1979), I think that understanding the organization of owl assemblages lies in how different sympatric owls use available prey resources; that is, in the study of the trophic structure of owl assemblages.

OBJECTIVES AND METHODS

I examined trophic structure of some Nearctic, Neotropical, and Palearctic owls by scrutinizing four levels of aggregation: the single owl population, the owl assemblage (>2 species), the raptor assemblage (owls and hawks), and the predator assemblage (owls, hawks, mammalian carnivores and snakes). Specific questions asked were: first, What is the trophic structure of owl assemblages (i.e., Do sympatric owl species segregate in their use of prey, or do they converge upon some particular prey, thus forming trophic guilds)? Second, What is the effect of including other sympatric predators in analyses of trophic structure (i.e., If trophic guilds exist are they composed solely of owls or include other predator types)? Third, Does trophic structure remain constant or change geographically? Fourth, If the latter is verified, what may be the underlying causes for changes in trophic structure?

With these questions in mind, I first examined quantitative information on the diet of sympatric (not necessarily syntopic) raptors in a number of localities in Nearctica: Michigan, Wisconsin and Utah; Neotropica: central Chile; and Palearctica: southern Spain. Published information (Errington 1932, 1933; Craighead and Craighead 1956; Valverde 1967; Smith and Murphy 1973; Jaksic et al. 1981) is based on analysis of regurgitated pellets (obtained mainly during the breeding season) including very detailed identification of their prey contents (to species level in the case of vertebrates). Based on such data, I constructed diet matrices and calculated all pairwise diet overlaps (i.e., diet similarities, using Pianka's 1973 formula) among sympatric species in all assemblages (see original data in Jaksic 1982). Diet matrices were subjected to UPGMA (Unweighted Pair Group Method with Arithmetic Average) clustering technique (Sneath and Sokal 1973) to obtain similarity dendrograms depicting trophic structure of each assemblage.

Secondly, I examined trophic structure of three predator assemblages (central Chile: Jaksic et al. 1981; southern Spain: Jaksic and Delibes 1987; central California: Jaksic, in prep.) for which the diets of all (or most) sympatric predatory vertebrates (i.e., owls, hawks, mammalian carnivores and snakes) were known. Thirdly, I reanalyzed results on geographic variation in trophic structure of European owl assemblages as documented by Herrera and Hiraldo (1976). Although Mikkola (1983) provides a more thorough data set (E. Korpimäki, pers. comm.), I found that Mikkola's results generally coincided with those of Herrera and Hiraldo (1976). Fourth, I summarized geographic variation of trophic metrics for owls of the genus *Athene* (Jaksic and Marti 1981), *Tyto* (Jaksic et al. 1982), and *Bubo* (Jaksic and Marti 1984). Trophic metrics summarized were diet breadth (or trophic diversity, using

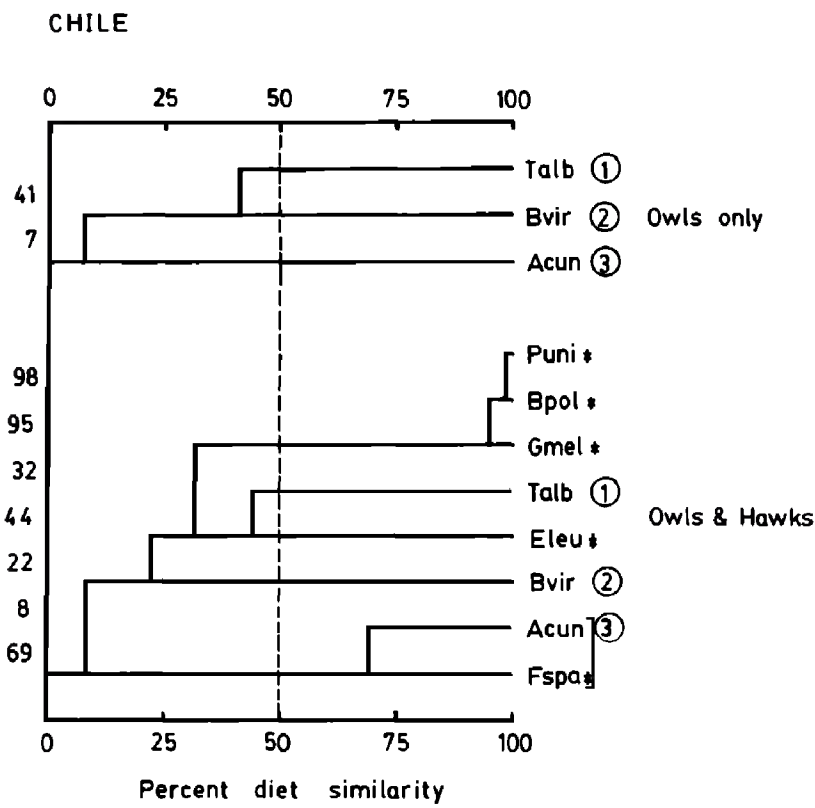
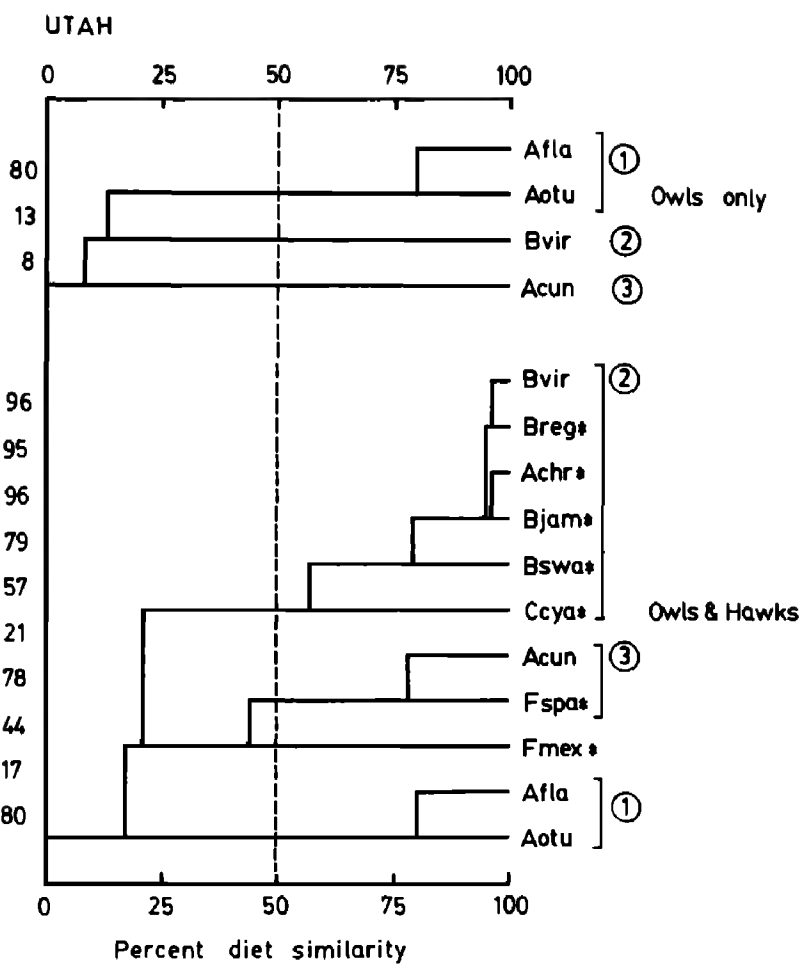
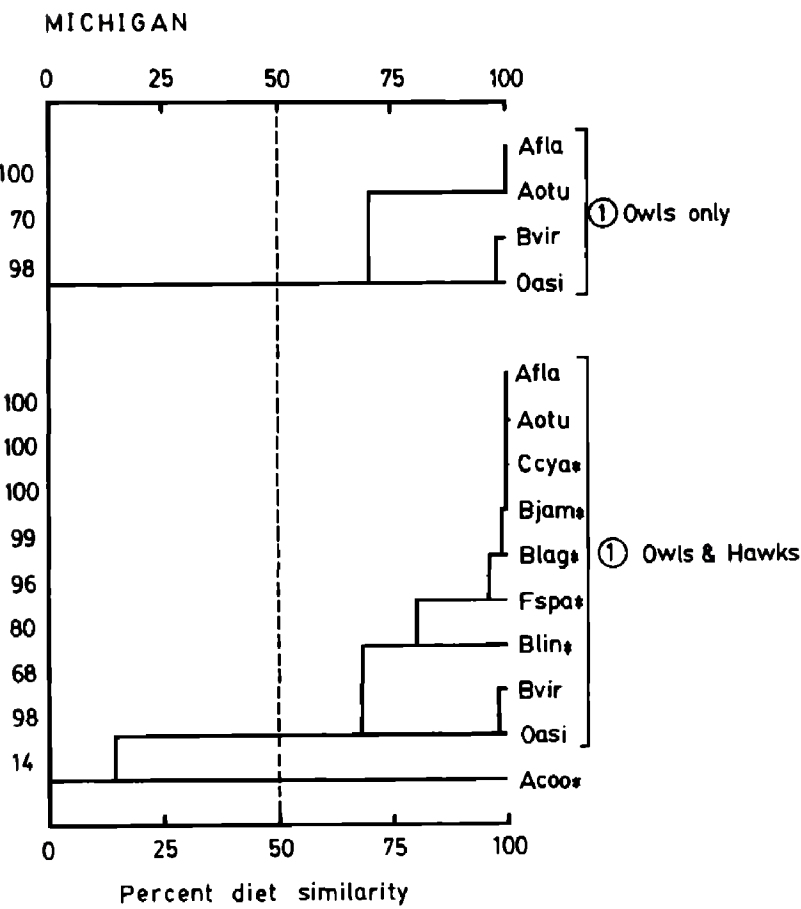
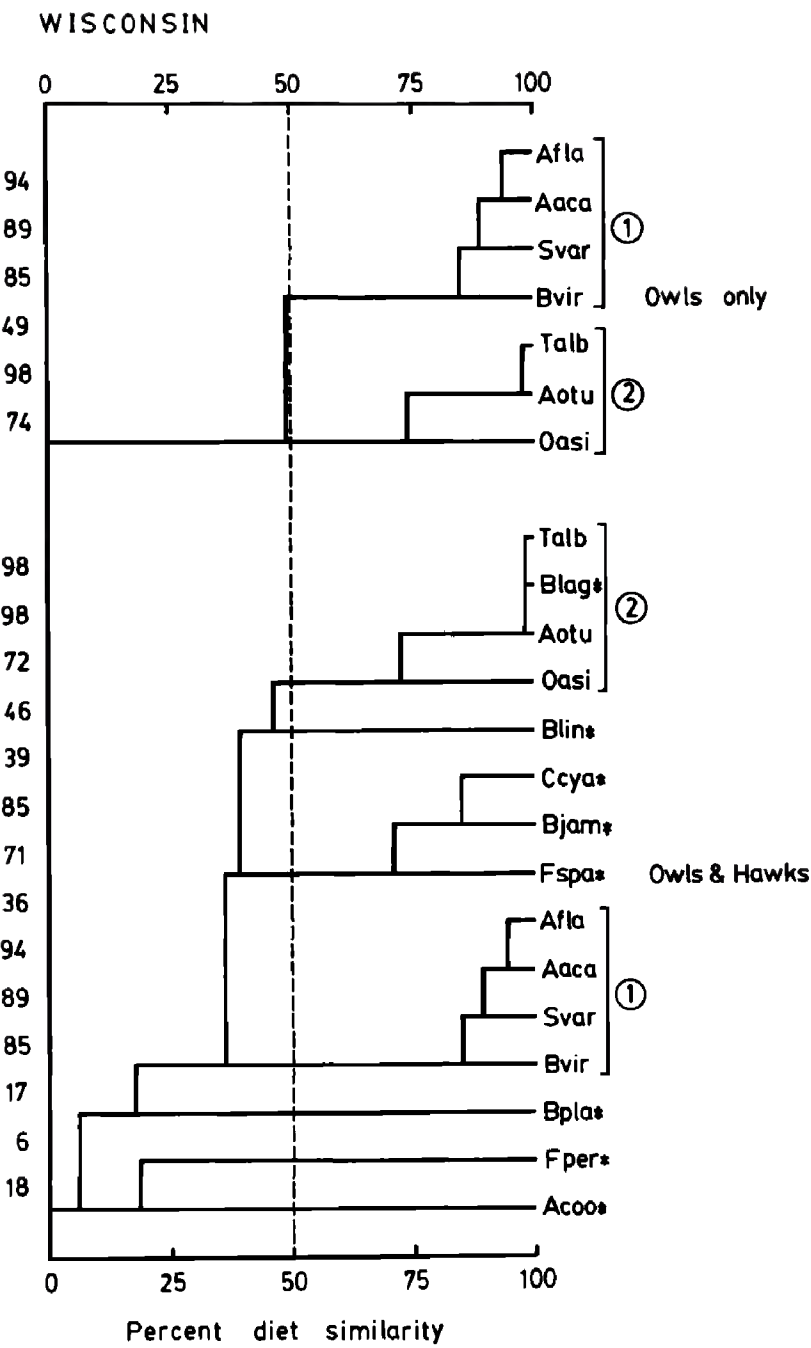
Herrera's 1974 formula), and arithmetic mean prey weight (see Jaksic and Marti 1981).

RESULTS

I first focus on trophic patterns shown by owls only before including sympatric hawks in a reanalysis of data sets. Using 50% diet similarity as an arbitrary minimum for assigning guild membership, two owl trophic guilds can be identified in Wisconsin (Fig. 1A). When sympatric hawks are included in the analysis, one owl guild expands to incorporate a hawk species. In Michigan (Fig. 1B) the owl assemblage is more tightly structured forming a single trophic guild, which increases greatly in size (from four to nine species) when sympatric hawks are included in the analysis. In Utah (Fig. 1C) a single guild is recognized at the owl assemblage level, but three become apparent after consideration of sympatric hawks. A similar situation is verified in Chile (Fig. 1D), where no trophic guilds made up solely by owls can be recognized, but at least one becomes formed by an owl and a hawk species. In Spain (Fig. 1E) a two-species owl guild increases in size to three when sympatric hawks are considered.

Interestingly, raptor trophic guilds are frequently composed of both nocturnal owls and diurnal hawks, a condition that attests to the inadequacy of temporal segregation as a mechanism to reduce the presumed exploitation competition for prey species active both day and night (Jaksic 1982; Carothers and Jaksic 1984; Korpimäki 1987b). Work in progress at the Snake River Birds of Prey Area (J. R. Parrish, pers. comm.), however, suggests that for that raptor assemblage time is indeed an orthogonal dimension that can be partitioned to reduce co-use of prey resources.

But predator assemblages are not only composed of owls and hawks. What happens when one analyzes the trophic structure of all sympatric predators (including mammalian carnivores and snakes) in a locality? In central Chile (Jaksic et al. 1981) there are 11 common predators. The trophic structure of the assemblage is very simple (Fig. 2A): two owls (*Tyto alba* and *Bubo virginianus*) appear to specialize on different prey and *Athene cunicularia* clusters with *Falco sparverius*. The situation in southern Spain is more complex (Jaksic and Delibes 1987), where 25 predator species form different trophic associations (Fig. 2B). Among owls, *Tyto alba* and *Strix aluco* cluster, and *Athene noctua* and *Otus scops* do so with a variety of other predators. Other members of this



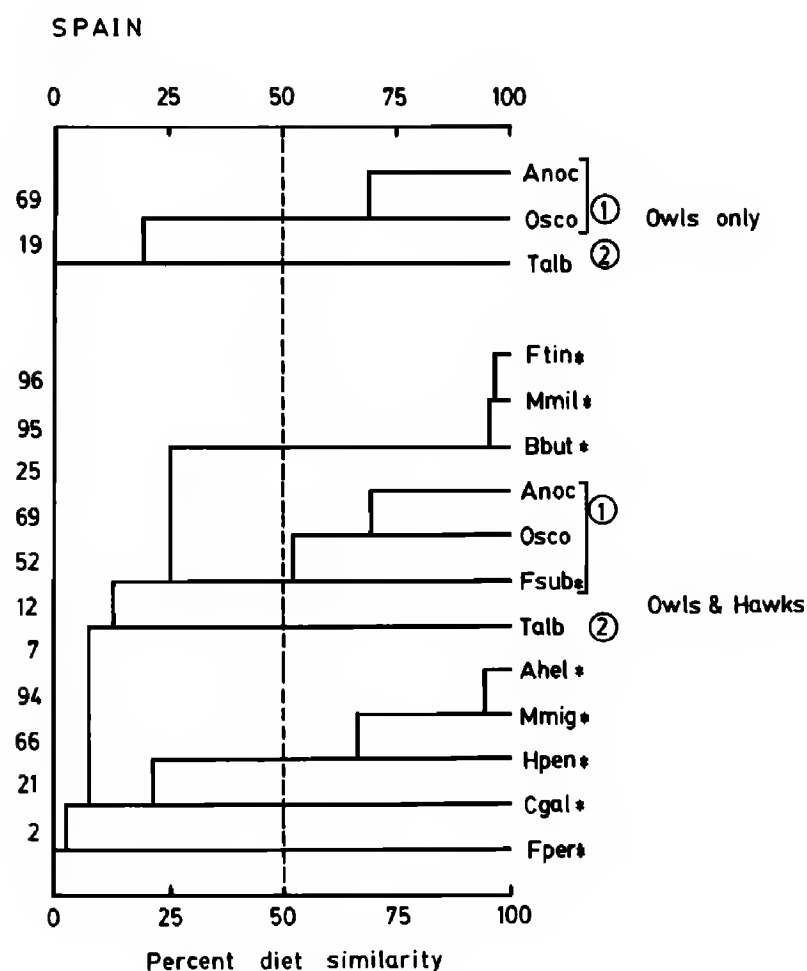


Figure 1. Trophic structure of owl and raptor assemblages in: A) Wisconsin, B) Michigan, C) Utah, D) Chile, and E) Spain. Using 50% diet similarity as the minimum to assign trophic guild membership, owl-only and owl-plus-hawk guilds are enclosed in brackets and assigned the same number for ease of identification. Names of owl species are as follows: Aaca = *Aegolius acadicus*, Acun = *Athene cunicularia*, Anoc = *Athene noctua*, Afla = *Asio flammeus*, Aotu = *Asio otus*, Bvir = *Bubo virginianus*, Oasi = *Otus asio*, Osco = *Otus scops*, Svar = *Strix varia*, Talb = *Tyto alba*. Names of hawk species (*) are: Achr = *Aquila chrysaetos*, Ahel = *Aquila heliaca*, Acoo = *Accipiter cooperii*, Bbut = *Buteo buteo*, Bjam = *Buteo jamaicensis*, Blag = *Buteo lagopus*, Blin = *Buteo lineatus*, Bpol = *Buteo polyosoma*, Bpla = *Buteo platypterus*, Breg = *Buteo regalis*, Bswa = *Buteo swainsoni*, Ccya = *Circus cyaneus*, Cgal = *Circaetus gallicus*, Eleu = *Elanus leucurus*, Fmex = *Falco mexicanus*, Fper = *Falco peregrinus*, Fspa = *Falco sparverius*, Fsub = *Falco subbuteo*, Ftin = *Falco tinnunculus*, Gmel = *Geranoaetus melanoleucus*, Hpen = *Hieraaetus pennatus*, Mmig = *Milvus migrans*, Mmil = *Milvus milvus*, Puni = *Parabuteo unicinctus*.

large guild are the hawk *Falco subbuteo* and the carnivores *Genetta genetta*, *Meles meles*, *Vulpes vulpes* and *Herpestes ichneumon*. In central California (Jaksić, in prep.) 11 predator species show the following trophic structure (Fig. 2C): *Tyto alba* does not belong to a guild, but a very complex guild is formed by *Bubo virginianus* and the hawk *Buteo jamaicensis*, the carnivores *Canis latrans* and *Urocyon cinereoargenteus*, and the snake *Crotalus viridis*.

Trophic nearest neighbors within owl guilds change geographically not only in number but also in taxonomic identity. A reanalysis of trophic structure of European owls (Fig. 3) based on data originally reported by Herrera and Hiraldo (1976) shows that *Asio otus*, *Aegolius funereus* and *Bubo bubo* belong to three different guilds in northern Europe but to a single guild in central Europe. Also, *Athene noctua* does not belong to the guild composed by *Strix aluco* and others in central Europe, but both belong to the same guild in southern Spain. *Tyto alba* and *Bubo bubo* dissociate from *Strix aluco* in southern Europe (these results coincide with those of Mikkola 1983). Korpimäki (1987a) has shown that geographical changes in owl guild composition may occur over relatively short distances.

Two major conclusions can be drawn from evidence so far presented. First, owl-only trophic guilds appear to be a rare phenomenon; instead, owls' trophic nearest neighbors are usually hawks, sometimes mammalian carnivores and even snakes (see also Phelan and Robertson 1978; Bradley 1983; Erlinge et al. 1984; Korpimäki 1984, 1985a, 1985b, 1987b). Secondly, nearest neighbors in trophic space (i.e., potential competitors) vary in number and identity across geographical ranges (see also Jaksić 1983; Mikkola 1983; Korpimäki 1987a).

In an attempt to find causes for variation in guild structure of owl assemblages, Carlos Herrera, Carl Marti and myself have examined trophic ecology of populations of *Athene*, *Tyto* and *Bubo* owls living in Chile, Spain and California (Jaksić and Marti 1981; Jaksić et al. 1982; Jaksić and Marti 1984). The areas chosen have similar climate, physiognomy and vegetation (di Castri et al. 1981), and taxonomic and size composition of owl assemblages are also similar (Jaksić 1983). Colorado owls were also included as a non-mediterranean outgroup. Owls present in these four localities are *Athene cunicularia* in Chile, *Athene cunicularia* in both California and Colorado and *Athene noctua* in Spain. *Tyto alba* is present in all four localities. *Bubo* owls are represented by *Bubo virginianus*.

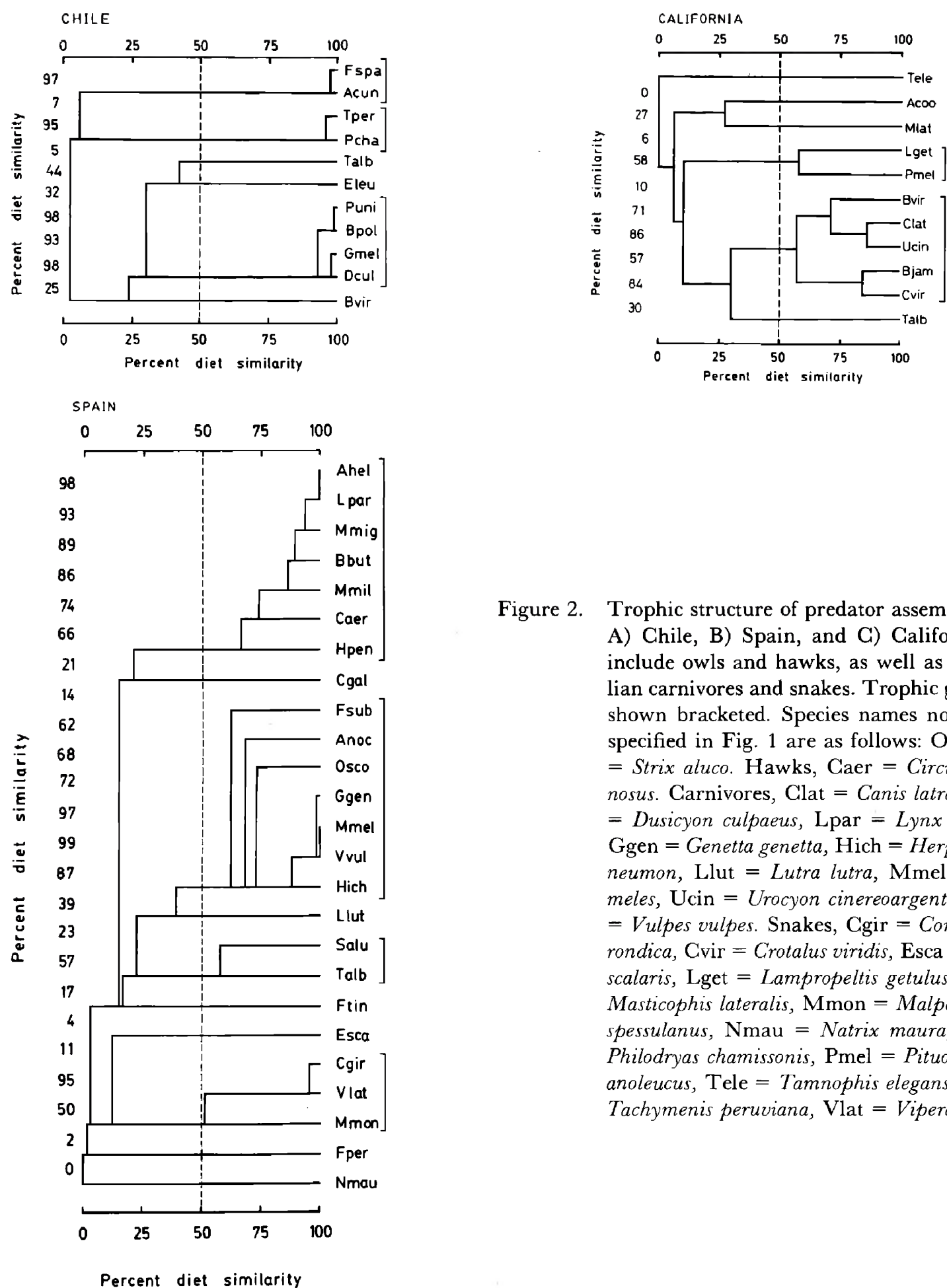


Figure 2. Trophic structure of predator assemblages in: A) Chile, B) Spain, and C) California that include owls and hawks, as well as mammalian carnivores and snakes. Trophic guilds are shown bracketed. Species names not already specified in Fig. 1 are as follows: Owls, Salu = *Strix aluco*. Hawks, Caer = *Circus aeruginosus*. Carnivores, Clat = *Canis latrans*, Dcul = *Dusicyon culpaeus*, Lpar = *Lynx pardinus*, Ggen = *Genetta genetta*, Hich = *Herpestes ichneumon*, Llut = *Lutra lutra*, Mmel = *Meles meles*, Ucin = *Urocyon cinereoargenteus*, Vvul = *Vulpes vulpes*. Snakes, Cgir = *Coronella girondica*, Cvir = *Crotalus viridis*, Esca = *Elaphe scalaris*, Lget = *Lampropeltis getulus*, Mlat = *Masticophis lateralis*, Mmon = *Malpolon monspessulanus*, Nmau = *Natrix maura*, Pcha = *Philodryas chamissonis*, Pmel = *Pituophis melanoleucus*, Tele = *Tamnophis elegans*, Tper = *Tachymenis peruviana*, Vlat = *Vipera latasti*.

ianus in Chile, California and Colorado and by *Bubo bubo* in Spain.

Trophic metrics computed plus mean weight of owls from different localities are presented in Table 1 for *Athene*, *Tyto* and *Bubo*. Diet breadths of the

four owl populations vary widely and inconsistently, with rank orders varying from site to site and showing clear crossovers (Fig. 4A). The same is observed in the case of the mean prey weights (Fig. 4B), as standardized by mean weight of corresponding owl

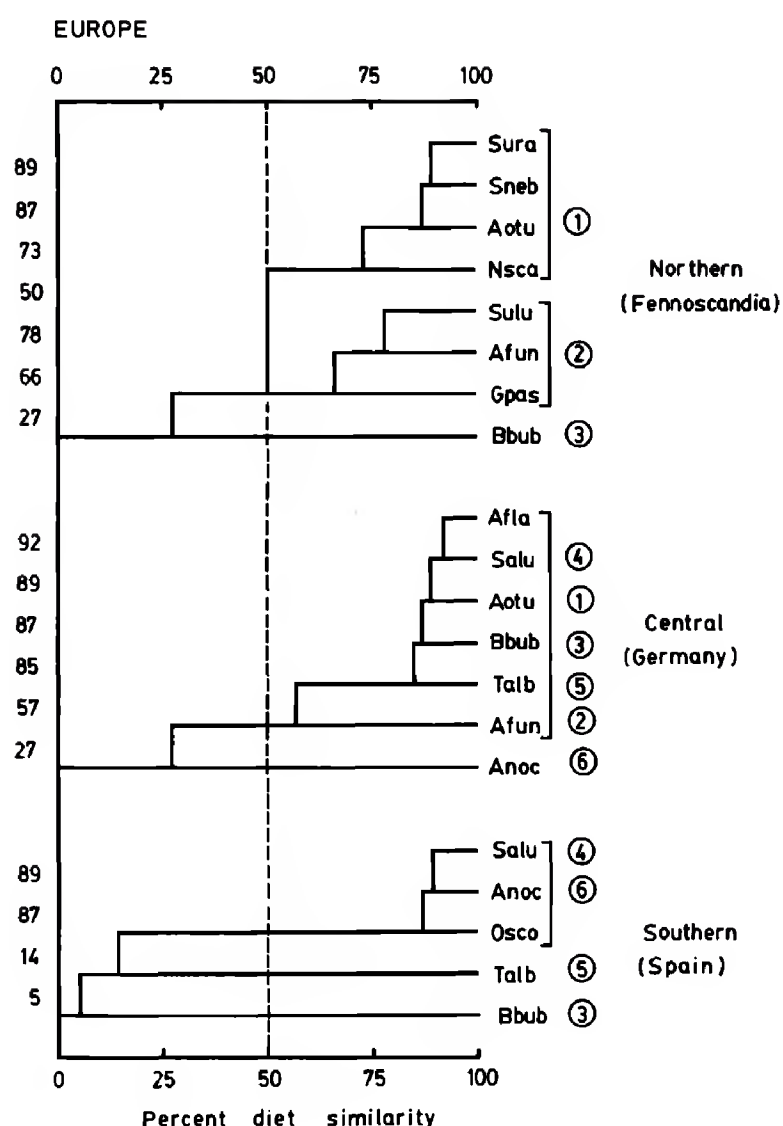


Figure 3. Trophic structure of owl assemblages in different regions of Europe (modified from Herrera and Hiraldo 1976). Trophic guilds are shown bracketed. A species that is present in more than one region is given the same serial number to aid in its localization. Names of owl species not already specified in Figs. 1 or 2 are as follows: Afun = *Aegolius funereus*, Bbub = *Bubo bubo*, Gpas = *Glaucidium passerinum*, Nsca = *Nyctea scandiaca*, Sneb = *Strix nebulosa*, Sura = *Strix uralensis*, Sulu = *Surnia ulula*.

populations. Notice that owls of different sizes vary markedly in relative prey weights, showing reversals and crossovers in rank orders.

These results suggest that each owl population responds individually, and perhaps opportunistically, to the local profile of prey sizes and abundances (see also Korschgen and Stuart 1972; Phelan and Robertson 1978; Korpimäki 1984, 1985a, 1985b, 1986a; Janes and Barss 1985; but see Nilsson 1984; Korpimäki 1987b; Korpimäki and Sulkava 1987, to the contrary). Further, owl populations seem to exploit prey resources with no regard for fixed optimal

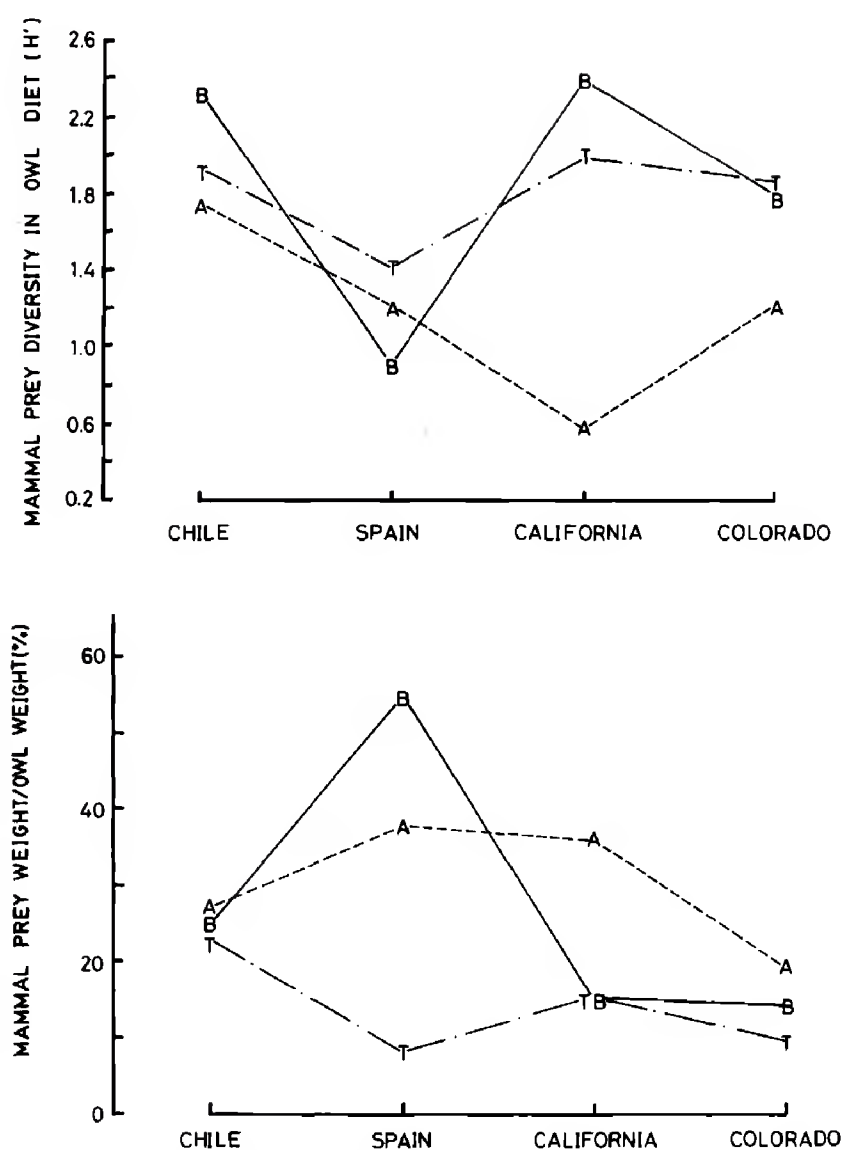


Figure 4. Trophic diversity (diversity of mammal prey in the diet), and relative prey weight expressed as percentage (weight of mammal prey in the diet relative to owl weight, as reported in Table 1) of owls in Chile, Spain, California, and Colorado. Symbols mean as follows: A = *Athene*, B = *Bubo*, T = *Tyto*.

prey size or diet breadth (see also Jakšić and Braker 1983; Janes and Barss 1985; Ekman 1986). Apparently, varying characteristics of trophic structure of owl assemblages emerge from idiosyncratic behavior within local owl populations.

DISCUSSION

Several theoretical and practical implications emerge. First, the significance of time as a niche axis for separation of owls and hawks cannot be sustained under the tenets of classic competition theory. Interference interactions between hawks and owls, rather than presumed exploitation competition, may be a major factor underlying their different activity times (see Jakšić 1982; Carothers and Jakšić 1984; Korpimäki 1987b). It should be interesting to explore why owls have not more thoroughly invaded

Table 1. Trophic metrics used to characterize congeneric owls in different localities. Trophic diversity was calculated at the species level of mammalian prey, and mean prey size also refers to mammalian prey only. Figures in parentheses are sample sizes; standard errors for mean prey size and mean owl size are provided in Jaksic and Marti (1981, 1984) and Jaksic et al. (1982).

TROPHIC METRICS				
SPECIES	CHILE	SPAIN	CALIFORNIA	COLORADO
Trophic diversity				
<i>Athene</i>	1.741 (503)	1.213 (8)	0.574 (896)	1.215 (388)
<i>Tyto</i>	1.932 (3417)	1.409 (12 492)	1.988 (7832)	1.856 (4305)
<i>Bubo</i>	2.314 (735)	0.897 (2281)	2.396 (2235)	1.803 (2141)
Mean prey size (g)				
<i>Athene</i>	67.3 (503)	56.0 (8)	55.2 (896)	29.0 (388)
<i>Tyto</i>	70.7 (3391)	21.2 (12 351)	68.2 (7827)	45.9 (4305)
<i>Bubo</i>	303.3 (660)	1037.9 (2277)	179.7 (2222)	207.1 (2141)
Mean owl size (g)				
<i>Athene</i>	247.0 (3)	148.0 (30)	154.0 (19)	150.5 (9)
<i>Tyto</i>	306.5 (8)	280.6 (20)	442.1 (15)	479.0 (?)
<i>Bubo</i>	1227.2 (6)	1885.5 (8)	1166.1 (30)	1460.3 (14)

the diurnal hunting period (indeed, *Asio flammeus*, *Athene* spp., *Glaucidium* spp., *Nyctea scandiaca*, *Strix aluco*, *S. nebulosa*, *S. varia* and *Surnia ulula* have made a partial transition to diurnality).

Secondly, temporal partitioning by owls (or other vertebrate predators) may not serve to reduce presumed resource exploitation but to minimize resource depression (see Charnov et al. 1976; Nilsson et al. 1982; Maurer 1984; Korpimäki 1987b): reduced availability of prey owing to their behavioral response to hunting predators. Although owls were not considered by Nilsson et al. (1982) to hunt for “evasive” prey such as birds and medium-sized mammals, I think the idea that owls may indeed depress their small mammal prey deserves testing. The role of different hunting modes as a means of alleviating resource depression deserves more attention (Jaksic 1985; Jaksic and Carothers 1985; Korpimäki 1986b). On the other hand, temporal partitioning may be an epiphenomenic response that serves to minimize frequency of agonistic encounters with aggressively dominant owls (Mikkola 1976; Jaksic 1982; Mikkola 1983), rather than a direct consequence of exploitation competition.

Thirdly, if habitat is only the arena in which owls dispute access to prey resources, perhaps habitat partitioning is also a means to minimize resource depression rather than presumed exploitation competition (see Maurer 1984). What would be the effect of removing dominant owls (e.g., *Bubo virginianus*, *B.*

bubo or *Strix uralensis*) on the abundance and diversity of local predator assemblages (see Rudolph 1978; Mikkola 1983; Korpimäki 1987a; for hints)? Why are there often fewer sympatric species of owls than hawks (Jaksic 1983)? What are the relative abundances of sympatric predators in the same guild? These questions deserve further research.

On the practical side, extrapolation of trophic characteristics of known owl populations is risky (even between comparable habitats), and the set of guild members is unpredictable (and often includes more than owls). Consequently, conservation/management measures should be based on field studies that include not only the target species but all potential guild members. Applied studies should consider that the intensity of ecological interactions among owls and with other predators is mediated not only by exploitation of shared prey, but perhaps more strongly by aggressive dominance.

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SUPERNUMERARY PRIMARIES AND RECTRICES IN SOME EURASIAN AND NORTH AMERICAN RAPTORS

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ABSTRACT.—We found nine instances of supernumerary (extra) primary feathers in six raptor species and eight instances of extra rectrices in five species. We checked nearly 11 000 migrant raptors during banding (ringing) operations at Eilat, Israel during the springs of 1984–1986 and at Cape May Point, New Jersey, USA during the autumns of 1984 and 1985. In all but one case of extra primary, there was also a corresponding extra greater upperwing covert. Most extra feathers were on the right side, and all but one were functional and similar in length, shape and color pattern to adjacent feathers. Most extra primaries were located around P3 (P1 innermost); most extra rectrices were around T5 (T1 central). The presence of supernumerary primaries and rectrices appears to bestow no selective advantage but possibly a disadvantage and probably occurs uncommonly in many raptor species.

All individuals of an avian species usually possess the same number of primary and tail feathers, except for some members of the Families Gaviidae and Phasianidae (e.g., see Short 1967). Raptors in the Order Falconiformes normally have 10 primary remiges on each wing and 12 rectrices, except for some Old World vultures and Steller's Sea Eagle (*Haliaeetus pelagicus*), which normally have 14 rectrices (Brown and Amadon 1968; Cramp and Simmons 1982). A number of references describe supernumerary or extra primaries and rectrices in other avian species (e.g., DeRoo 1967; Scott 1969; Somadikarta 1984; Hammer 1985; Melville 1985); however, few published reports exist for raptors. Miller (1924) described a Hooded Vulture (*Necrosyrtes monachus*) with an extra primary, the only reported case we could locate. We did find three references to extra rectrices. Berger and Mueller (1958) captured an American Kestrel (*Falco sparverius*) with 13 tail feathers and cited references reporting extra rectrices for the Eurasian Goshawk (*Accipiter g. gentilis*) and Barbary Falcon (*Falco peregrinoides*). Melville (1985) found an injured Black Kite (*Milvus migrans*) with 13 rectrices, and Plater (1985) mentions a Northern Goshawk (*A. g. atricapillus*) that had 13 tail feathers. Grossman and Hamlet (1964), Brown and Amadon (1968), Newton (1979) and Cramp and Simmons (1982) make no mention of supernumerary primaries or rectrices.

Herein, we report nine instances of supernumerary primaries in six falconiform species and eight of supernumerary rectrices in five species. Additionally, we cite previously unreported instances of extra rectrices for five additional raptor species.

STUDY AREA AND METHODS

Raptors were captured at Eilat, Israel during the springs of 1984–1986 and at Cape May Point, New Jersey, USA during the autumns of 1984 and 1985 as part of long-term raptor migration banding (ringing) operations described in Clark (1976) and Clark et al. (1986). The number of primaries on each wing and the number of tail feathers were counted on every raptor captured. Individuals with supernumerary feathers were noted and photographed. Photographs of the wings and tails with extra feathers were compared to photographs of normal wings and tails of the same species to determine relative positions of extra feathers. Standard numbering of primaries and rectrices is used, with P1 being the innermost primary and T1 the central tail feather.

RESULTS

Supernumerary feathers occurred in seven raptor species (Table 1). Nine individuals (two adults, seven juveniles) captured were found to have an extra primary on one or both wings (Table 2, Fig. 1). Most extra feathers were on the right wing (Table 2), but one Sharp-shinned Hawk (*A. striatus*) and one Cooper's Hawk (*A. cooperii*) had an extra feather in the same location on both wings. Another Sharp-shinned Hawk had a short, misshapened primary on the left wing (Fig. 1b). Eight individuals (one adult, seven juveniles) were found to have extra rectrices (Table 1, Fig. 2). Most occurred on the right side (Table 2, Fig. 2), but one American Kestrel had an extra rectrix in the same location on both sides. One Merlin (*F. columbarius*) had an extra feather on the left side (Fig. 2b). All extra tail feathers and all but one extra primary appeared functional (i.e., their removal would have left a gap). We did not

Table 1. Occurrence by raptor species of supernumerary primaries and rectrices in Elat, Israel and Cape May Point, NJ, U.S.A.

SPECIES	NO. EXAM- INED	NO. CASES	
		PRIM.	RECT.
Honey Buzzard (<i>Pernis apivorus</i>)	2		
Black Kite (<i>Milvus migrans</i>)	91		
Bald Eagle (<i>Haliaeetus leucocephalus</i>)	1		
Egyptian Vulture (<i>Neophron percnopterus</i>)	1		
Marsh Harrier (<i>Circus aeruginosus</i>)	129		
Northern Harrier (<i>C. cyaneus</i>)	226		
Pallid Harrier (<i>C. macrourus</i>)	19		
Montagu's Harrier (<i>C. pygargus</i>)	11		
Northern Goshawk (<i>Accipiter gentilis</i>)	30		
Cooper's Hawk (<i>A. cooperii</i>)	658	1 ^a	2
Sharp-shinned Hawk (<i>A. striatus</i>)	6404	3 ^a	1
Eurasian Sparrowhawk (<i>A. nisus</i>)	53		
Levant Sparrowhawk (<i>A. brevipes</i>)	287	1	
Red-shouldered Hawk (<i>Buteo lineatus</i>)	31		
Broad-winged Hawk (<i>B. platypterus</i>)	8		
Swainson's Hawk (<i>B. swainsoni</i>)	1		
Steppe Buzzard (<i>B. b. vulpinus</i>)	1221	1	1
Red-tailed Hawk (<i>B. jamaicensis</i>)	328		
Long-legged Buzzard (<i>B. rufinus</i>)	27	2	
Rough-legged Hawk (<i>B. lagopus</i>)	3		
Steppe Eagle (<i>Aquila nipalensis</i>)	11		
Golden Eagle (<i>A. chrysaetos</i>)	1		
Bonelli's Eagle (<i>Hieraetus fasciatus</i>)	3		
Booted Eagle (<i>H. pennatus</i>)	30		
Lesser Kestrel (<i>Falco naumanni</i>)	11		
American Kestrel (<i>F. sparverius</i>)	451	1	2 ^b

Table 1. Continued.

SPECIES	NO. EXAM- INED	NO. CASES	
		PRIM.	RECT.
Eurasian Kestrel (<i>F. tinnunculus</i>)	101		
Northern Hobby (<i>F. subbuteo</i>)	13		
Merlin (<i>F. columbarius</i>)	676		2
Lanner Falcon (<i>F. biarmicus</i>)	2		
Peregrine (<i>F. peregrinus</i>)	98		
Barbary Falcon (<i>F. pelegrinoides</i>)	12		
Total	10 940	9	8

^a One bird captured had extra feathers on both wings.
^b One bird captured had an extra feather on both sides of tail.

find extra feathers in 25 additional species on the 1216 individuals checked (Table 1).

In all cases except the misshapened extra feather mentioned above, extra primaries occurred either between P2 and P3 or between P3 and P4. In addition there was an extra greater upperwing covert corresponding to each extra primary, again except for the short, misshapened feather mentioned above. Extra rectrices all appeared to occur between T4 and T5 or T5 and T6.

Nine cases of extra primaries and eight of extra rectrices, among almost 11 000 raptors checked, yielded a ratio of occurrence of approximately 1:1000 for each condition (Table 1).

Four additional, previously unpublished occurrences of supernumerary rectrices were reported to us. One juvenile female Eurasian Goshawk and one adult female Sparrowhawk (*A. nisus*) captured in Finland each had an extra rectrix on the right side (D. Forsman, pers. comm.). A captive-bred Harris' Hawk (*Parabuteo unicinctus*) had 14 tail feathers, one extra on each side (K. Titus, pers. comm.). A Prairie Falcon (*F. mexicanus*) had an extra tail feather on the right side (C. Munson, pers. comm.). In addition Clark captured an Eurasian Kestrel (*F. tinnunculus*) in Northern Israel that had an extra tail feather on the right side.

Some raptors were captured with less than the usual number of primaries or rectrices. However, we could not determine whether the missing feather was due to molt, injury or a missing feather follicle. Empty follicles corresponding to molted feathers can



Figure 1. Examples of supernumerary primaries. (Top) Right wing of adult male Levant Sparrowhawk showing extra feather between P2 and P3 or P3 and P4 (arrow). (Bottom) Left wing of juvenile female Sharp-shinned Hawk showing short, misshapened primary feather between P7 and P8 (arrow).

usually be detected by careful examination. An X-ray of the wing would be required to ascertain if follicles were missing (see Stresemann 1963).

DISCUSSION

Supernumerary feathers found in this study on all but one bird appeared to be normal and functional and were presumably replaced each year during an-

nual molt. Both the Sparrowhawk and Harris' Hawk mentioned above had extra feathers before and after a complete molt of tail feathers. Melville's (1985) Black Kite completed three tail molts, each time replacing the extra feather. DeRoo (1967) caught a Swift (*Apus apus*) in successive years which had extra tail feathers. Hammer (1985) captured six birds of various species with either extra or missing rectrices,

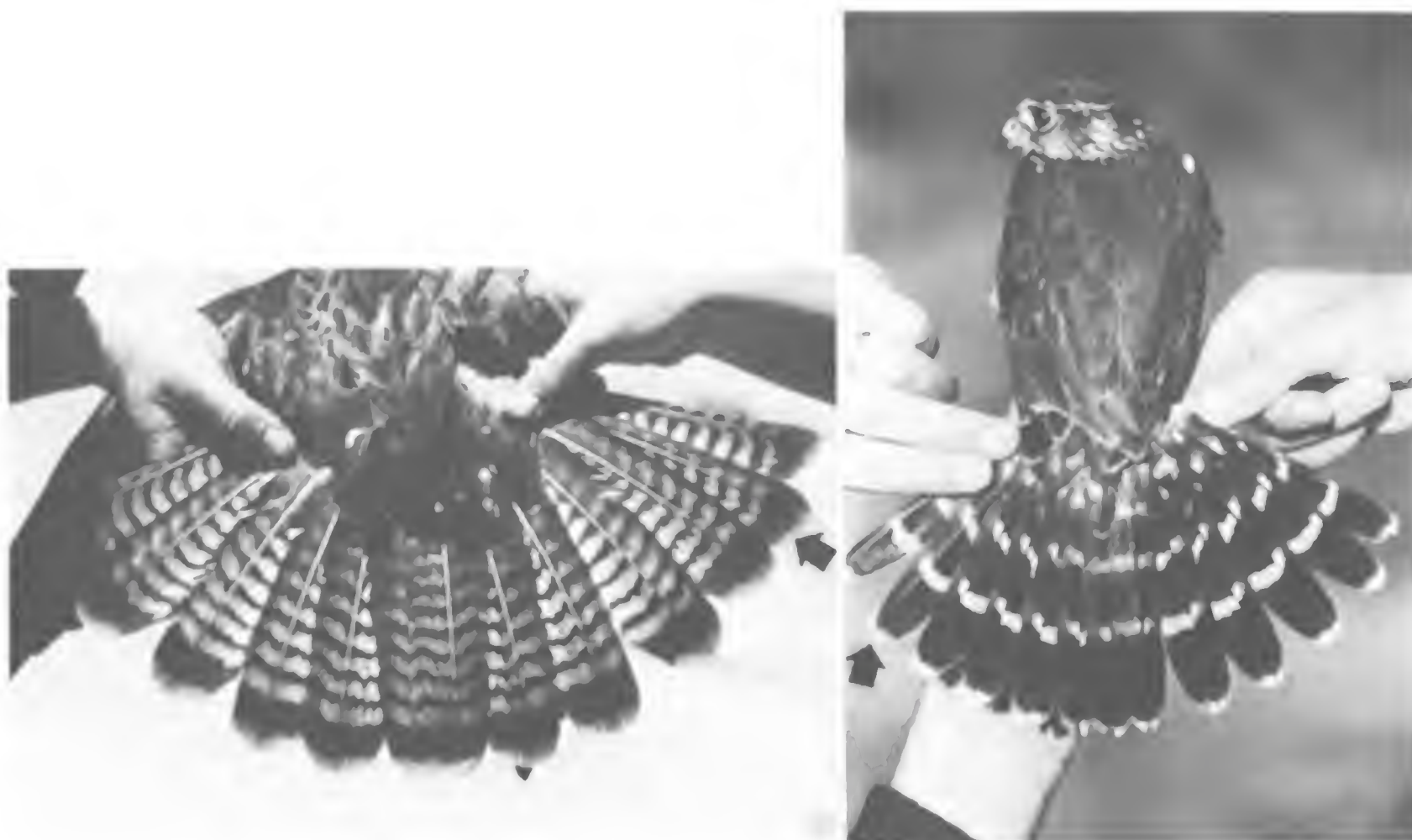


Figure 2. Examples of supernumerary rectrices. (Left) Tail of adult Steppe Buzzard showing extra feather on the right side near T5 (arrow). (Right) Tail of juvenile male Merlin showing extra feather on left side between T5 and T6 (arrow).

and the same birds were recaptured in the same condition a year or more later.

Hammer (1985) found a frequency of supernumerary rectrices of 0.2% (45 of 22 500 examined) for 23 passerine and non-passerine species, almost three times as frequent as our rate of 0.07% in raptors.

Fifteen (89%) of the supernumerary feathers we found occurred on the raptor's right side (Table 2). Stresemann (1963) reported four instances of extra right primaries. Melville (1985) found a Red-necked Stint (*Calidris ruficollis*) with an extra right primary. Miller (1924) reported two instances of extra right primaries, while Somadikarta (1984) cites nine instances of extra right rectrices but only two of left ones. Clearly a distinct bias exists for the location of extra primaries and rectrices to occur on the right for which we can offer no explanation at this time.

Melville (1985) believed that the extra primary he reported was positioned between P3 and P4. Stresemann (1963) used X-ray radiographs to determine

extra feather attachment to the metacarpus between P1 and P6, most likely between P5 and P6. Our close inspection of primary feathers showed that P1 to P4 are similarly shaped and progressively longer, with P5 to P10 having a different shape. Thus it appeared to us that extra primaries were in all but one case positioned between P1 and P4, as there were five similar, gradually longer feathers in this area compared to four on normal wings. We judged the extra feather to be inserted between P2 and P3 or P3 and P4 in all cases.

Tail feathers T1 and T6 are each distinctly shaped and patterned for most raptor species. T2 through T5 are more similar, but are usually slightly different in shape and length. Thus, determining where an extra feather was inserted was relatively easy. Forsman (pers. comm., op. cit.) felt that an extra rectrix on a juvenile Goshawk was T5 replicated. Berger and Mueller (1958) reported an extra rectrix positioned between T1 and T2 and reported that Awender thought his Eurasian Goshawk had an

Table 2. Position of supernumerary primaries and rectrices found on raptors in Eilat, Israel and Cape May Point, NJ, U.S.A.

SPECIES	INDIVIDUAL NO.	EXTRA FEATHER(S)	LOCATED BETWEEN
Cooper's Hawk	1	1 Right & 1 Left	P2-P3
	2	1 Right	P2-P3 T4-T5 or T5-T6
	3	1 Right	T5-T6
Sharp-shinned Hawk	1	1 Right & 1 Left	P2-P3
	2	1 Right	P2-P3
	3	1 Left*	P7-P8
	4	1 Right	T4-T5 or T5-T6
Levant Sparrowhawk	1	1 Right	P2-P3 or P3-P4
Steppe Buzzard	1	1 Right	P2-P3 or P3-P4
	2	1 Right	T4-T5 or T5-T6
Long-legged Buzzard	1	1 Right	P2-P3 or P3-P4
	2	1 Right	P2-P3 or P3-P4
American Kestrel	1	1 Right	P2-P3
	2	1 Right & 1 Left	T4-T5 or T5-T6
	3	1 Right	T4-T5
Merlin	1	1 Right	T5-T6
	2	1 Left	T5-T6

* Short, misshapened feather.

extra feather between T4 and T5. A consensus position for supernumerary rectrices thus appears to be a replication or close replication of T5.

Both adult and juvenile raptors having extra feathers were captured at Eilat. However, no adults with extra feathers were caught at Cape May Point, probably because fewer than 10% of raptors captured are adults (Clark 1985a, 1985b).

Further investigation is required to determine if this phenomenon is the result of genetic anomaly and therefore could be inherited by offspring. Supernumerary primaries and rectrices appear to offer no selective advantage to birds but could offer dis-

advantages. Further studies on flight dynamics of raptors with extra remiges and rectrices may show adverse effects due to asymmetry or imbalance. Judging from our findings, the phenomenon is probably widespread but uncommon in various raptor species.

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SHORT COMMUNICATIONS

DUSTING IN FALCONS

DIETER SCHMIDL

Birds keep their plumage in good condition with routine maintenance, including bathing, drying, oiling, powdering, preening and plumage scratching. Such behaviours form a homogeneous functional group to which the activities of dusting, sunning, anting and even smoke-bathing could be subsidiary (Campbell and Lack 1985). Falcons (Family Falconidae) have been reported to use several different methods of "bathing": stand-in bathing while standing or crouching in shallow water, flight-bathing on the wing through a series of dips and rises, rain-bathing on a perch or on the wing and snow-bathing (see Cade 1960; Herren 1960; Fischer 1967; Lauer 1968; Keicher 1969; Glutz von Blotzheim et al. 1971). Other methods are sun-bathing (Ristow et al. 1980; Cade 1985) and dusting—the terms *dust-bathing* and *sand-bathing* have been rejected by Campbell and Lack (1985: 161), who restricted the term *bathing* to true bathing in water (Heinroth and Heinroth 1927; Glutz von Blotzheim et al. 1971; Ostermüller 1973; Ristow et al. 1980; Schmidl 1985; Holthuijzen et al. 1987). Anting (Potter 1970) and smoke-bathing (Prideaux 1947) have not been reported for falcons. Observations of dusting in falcons indicate two different patterns: dusting while *lying* and dusting while *sitting*, two patterns which correspond to dusting behaviour of pigeons (Family Columbidae) and, according to Nicolai (1962), may be regarded as evolutionary steps in the development of dusting behaviour.

Dusting is "a highly specialized, stereotyped behaviour of birds whereby 'dust' (fine earth, sand, etc.) is deliberately introduced into the plumage and later expelled . . . Dusting bouts are typically organized in three main phases, often repeated: 1) loosening substrate if necessary and formation of dusting hollows or wallows by scraping and digging; 2) tossing dust into and onto plumage and rubbing the head in dust; 3) ruffling dust through the plumage and shaking it out. Though the dusting bird may stand initially, it squats or lies down for most of the bout with feathers ruffled and wings drooped, often rotating its body, rising from time to time and at the end to shake" (Campbell and Lack 1985:161). Recent evidence for the function of dusting in birds strongly suggests that "dusting helps in feather maintenance, either on its own or in combination with the head-scratching and preening that intersperse or follow bouts. Experiments on quails (Statkiewicz and Schein 1980) indicate that regular dusting maintains the

optimum amount of oil on the plumage by removing excess preen-oil and other feather lipids, these being absorbed by the dust and then removed with it plus any dry skin, feather debris, etc. The plumage of birds deprived of the opportunity to dust becomes oily and matted within a few days" (Campbell and Lack 1985:162). Other functions include the treatment of ectoparasites (the absence of such parasites at times when the behaviour occurs does not disprove the theory) and their discouragement (Wink et al. 1979; Holthuijzen et al. 1987).

Specific observations of dusting in falcons are not as detailed as the general description given above. Glutz von Blotzheim et al. (1971:733), for example, mention that "Kestrels *Falco tinnunculus* seem to enjoy sand or dust baths, they dip their heads, beat their wings and waggle their tails while performing the typical bathing motions" (cf. Heinroth and Heinroth 1927:108; Boyle 1952; Giese 1955; Glutz von Blotzheim et al. 1971:733). In the Lesser Kestrel (*Falco naumanni*) "the feathers are ruffled and the head tucked in; the wings, drooping on either side, are beaten against the body and the feet make rapid scratching movements (Bernhauer in Glutz von Blotzheim et al. 1971: 763). Dusting Prairie Falcons (*Falco mexicanus*) "shuffled their abdomens through the fine sand with the feathers fluffed out and their wing and tail feathers extended, and frequently made dipping motions with their heads and bodies" (Holthuijzen et al. 1987:135). Wickler and Seibt observed a dusting Lanner Falcon (*Falco biarmicus biarmicus*) in Natal, South Africa, "the bird lay half on its right side, the underside of the right-hand wing lay on the ground, its head pointed towards us, chin on the ground. It scratched in the sand with one leg, at least, and shook itself, as dust rose several times" (Schmidl 1985). Eleonora's Falcon (*Falco eleonora*) "usually lies, with all feathers spread, in the dust pan trying to collect the dust under its body; with vigorous movements the dust is cast up and collected in the feathers. Sometimes the falcon rests with wings spread apart, thereby combining sun- and dust-bathing" (Ristow et al. 1980:54). The Gyrfalcon (*Falco rusticolus*) (E. Müller, pers. comm.) and Peregrine Falcon (*Falco peregrinus*) (Walliser in Glutz von Blotzheim et al. 1971:906; G. Speer, pers. comm.; R. W. Nelson, pers. comm.) also take opportunistic dust baths. Ostermüller (1973:65) observed "a male Peregrine Falcon at a breeding place in Northern Germany. It circled in sunny dry weath-

er (22°C) over a rock promontory and then swooped from a great height onto a freshly ploughed field bare of vegetation. There he sprang forwards in three or four rapid leaps of about 0.5 m (leaps resembling those of black-birds *Turdus merula*, checked and then repeatedly bent forward and shook his plumage. The movements matched those of a Peregrine bathing in water, as caught in a photograph by Fischer 1967:61)." The position of this Peregrine is reproduced in Fig. 1A.

Cited, but not necessarily representative observations for the different species nevertheless indicate that falcons show two different patterns:

- 1) dusting while *sitting*—the falcon squats on the tarsal joint and makes motions similar to water-bathing (Fig. 1A, B);
- 2) dusting while *lying*—the falcon lies on the ground ruffling dust through the plumage like dusting in galliform birds (Fig. 1C), a process of falcon nest-hollowing using scratching; although in it no vigorous dusting and shaking of the plumage occurs.

Patterns could be regarded as evolutionary steps in the development of well-coordinated dusting behaviour, as shown in pigeons (Family Columbidae) (Nicolai 1962). By comparing a variety of pigeon species Nicolai was able to show how the change from water-bathing to dusting may have evolved. Although dusting behaviour is unusual in columbids, the Galapagos Dove (*Nesopelia galapagoensis*) after bathing in water often initiates dust-bath movements, possibly while sitting, with more or less distinct "scratching of sand up into the plumage" with the beak. The Bare-faced Ground Dove (*Metropelia ceciliae*), an inhabitant of dry highlands in Peru and Chile, even shows dusting behaviour in a lying position as do galliform birds. Such is compatible with Campbell and Lack's (1985:161) statement that dusting is "most characteristic of species living in or originated from bare open habitats, particularly desert, steppe and savanna, where water for bathing—especially of the 'stand-in' type—is scarce or absent."

As in columbids, dusting is unusual in raptors (Ristow et al. 1980:55) but has been observed in the Peregrine Falcon in a sitting position (Ostermüller 1973:65), and for a lying position in the Lanner Falcon (Schmidl 1985) and probably the Prairie Falcon (Holthuijzen et al. 1987:135) and Eleonora's Falcon (Ristow et al. 1980), the last three inhabiting open and arid biotopes. If, according to Nicolai (1962), dust-bathing has evolved from bathing in water, then dusting in lying position should presumably be the most developed form. At present, insufficient data prevent the demonstration of a similar evolutionary sequence of dusting in falcons, and therefore systematic observations are required.

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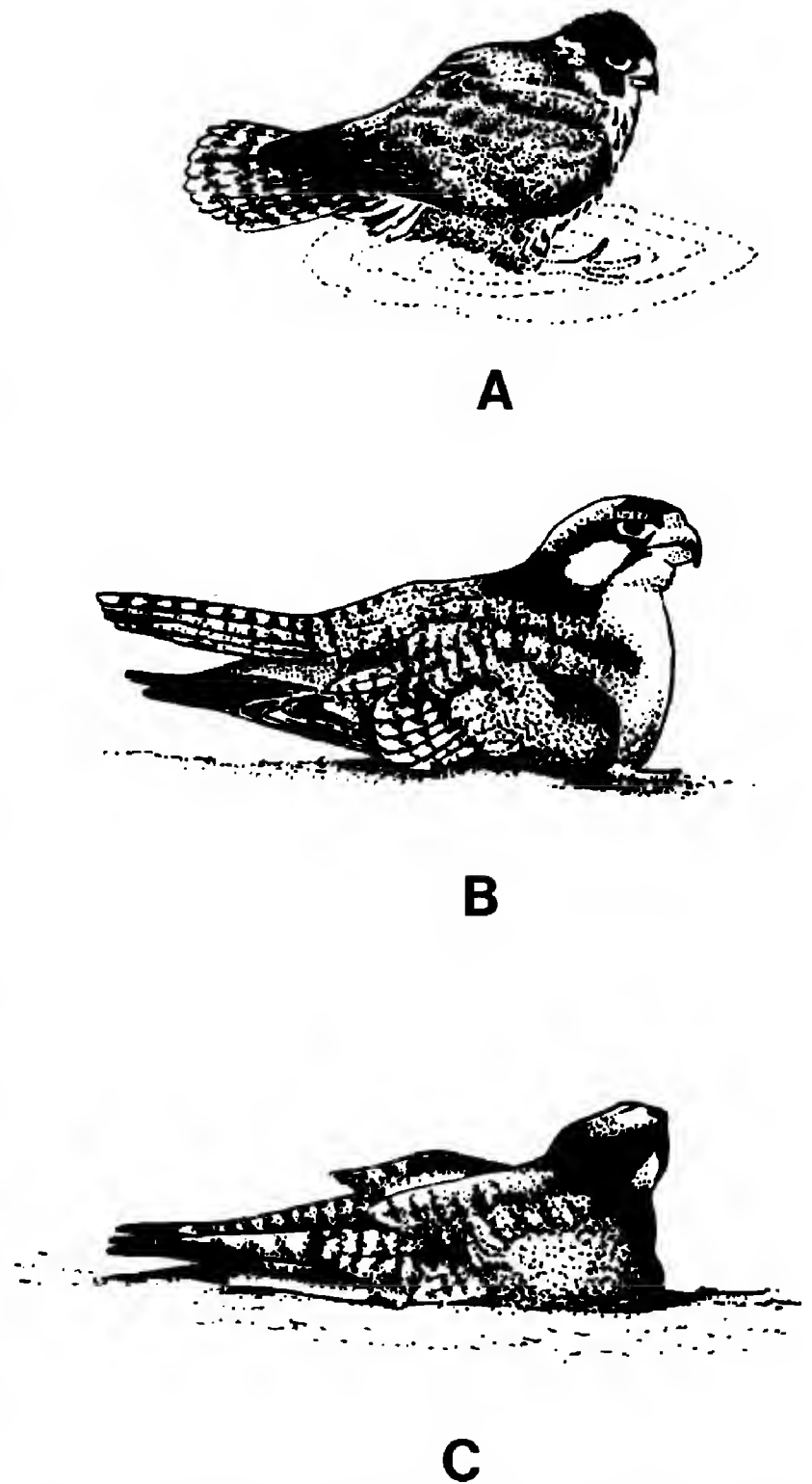


Figure 1. Bathing and dusting behaviour in falcons. A) Peregrine Falcon bathing in water (after Fischer 1967:61). B) Lanner Falcon dusting in sitting position (after Schmidl 1985). C) Lanner Falcon dusting in lying position (after Schmidl 1985).

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Stephen R. Tully Memorial Grant. Raptor Research Foundation and Tully family announce the availability of a \$500 grant to provide financial assistance to promote the research, management, and conservation of birds of prey. Individuals demonstrating serious interest in raptors, particularly students and amateurs with limited access to major granting agencies, are eligible.

Applicants must send three copies of the following: resume (vitae), specific study objectives, an account of how funds will be spent, and a statement indicating how the proposed work would relate to other work by the applicant and to other sources of funds. **Information must be postmarked by September 15, 1988.** Send to **Stephen R. Tully Memorial Grant, 5666 West Flying Hawk Lane, Boise, Idaho 83709.** Grant awards will be announced at the annual Raptor Research Foundation meeting October 26-28, 1988 at Minneapolis, Minnesota. **Note:** Persons wishing to contribute to this and future Tully Grants may make their checks payable to Raptor Research Foundation/Tully Grant and send to the above address.

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GREAT HORNED OWLS (*Bubo virginianus*) NESTING IN A
GREAT BLUE HERON (*Ardea herodias*) HERONRY

GARY BURKHOLDER AND DWIGHT G. SMITH

From 1981–1987 we studied nesting ecology of Great Blue Herons (*Ardea herodias*) at a heronry located at Knox Lake, Knox County, Ohio. Knox Lake was created in 1955 for flood control, and the heronry was located in the remains of a mixed mesophytic woodland which was destroyed following flooding. Standing trees were leafless and in various stages of decay. In 1981, 1982, 1983 and 1984 Great Horned Owls (*Bubo virginianus*) used heron nest sites for breeding. Herein we report our observations of Great Horned Owl nest site selection, breeding chronology and reproductive efforts within the heronry.

Great Horned Owls used nests constructed by Great Blue Herons in previous years: nest bowls contained feathers but were otherwise unaltered. All nests used were in trees located in the interior of the heronry. Typically each tree contained from two to seven nests placed at varying heights; Great Horned Owls used nests located in the middle of the remaining limbs of the dead trees while Great Blue Herons occupied nests in the upper limbs of trees but did not use nests below or adjacent to an active owl nest until the owlets fledged or the nest was deserted. Minimum observed distances between active heron and owl nests were about 2 m. In 1982, 1983 and 1984 herons occupied and repaired several of the unused adjacent and lower nests after owls had departed the nest tree area. Reluctance to use nests near active owl nests may have been influenced partly by the behavior of the young owls, which usually left the nest at 2–3 wks of age to move about on adjacent limbs.

Although not actually observed, backdating (Anderson and Hickey, *Wilson Bull.* 82(1):14–28, 1970) from the time young were first recorded in the nests suggests that nest

site selection by owls occurs in February, shortly before Great Blue Herons arrive; thus, the owls usurp the nest of their choice. Incubation dates ranged from 5 March–7 April, while earliest dates in which young were found in nests were 1 April–7 May. Earliest observed fledging date was 8 May but young typically fledged in late May or early June. Comparatively, herons arrived in late February and early March and apparently selected and began to repair nests shortly thereafter. Heron eggs were laid in late March and early April and young were in the nest from late April through June and sometimes July.

Great Horned Owl nests averaged 2.5 young/nest (range one–three) but in 2 of the 4 yrs young did not fledge. In both years disappearance of the 2–3-wk-old young occurred during a period of severe storms and associated high winds.

Although infrequently reported, the use of heron nests by Great Horned Owls is apparently widespread: Bent (U.S. Natl. Mus. Bull. 170, Pt. 2, 1938) recorded owl use of nests of larger herons in Canada and the eastern United States and Black-crowned Night Heron (*Nycticorax nycticorax*) nests in California. In central Utah we have found both Great Horned Owls and Long-eared Owls (*Asio otus*) nesting in a Great Blue Heron heronry along the western edge of Utah Lake, Utah County, in 1969 and 1982.

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THE EFFECT OF KLEPTOPARASITIC PRESSURE ON HUNTING BEHAVIOR AND PERFORMANCE OF HOST MERLINS

JOSEPH B. BUCHANAN

Kleptoparasitism, or food piracy, is widespread among birds and is most prevalent among Order Falconiformes and Order Charadriiformes (Brockmann and Barnard 1979). Among the Falconiformes, 10 North American species are known kleptoparasites (Paulson 1985); seven species kleptoparasitize other raptors (Brockmann and Barnard 1979). In this paper I document and describe kleptoparasitic activities directed at host Merlins (*Falco columbarius*) during winter in western Washington. In addition I describe how kleptoparasitism may influence hunting tactics and performance by host Merlins.

Observations were made during winter (Nov-Mar) 1979-1987 at several estuarine sites in western Washington as part of a study on the relationship between Merlins and their primary prey, Dunlin (*Calidris alpina*) (Buchanan et al. 1988). One hundred and eleven hunting flights by Merlins (with known outcomes) were observed in that study (1979-1985), and an additional 22 flights were observed subsequently; all were directed at Dunlins.

I compared behavior and performance of hunting Merlins when other raptors were both present and absent. Raptors were considered present only if they were judged close enough to successfully attack a Merlin with prey before the Merlin could reach cover (a distance usually of ca. 200 m). Glaucous-winged Gulls (*Larus glaucescens*) also kleptoparasitized Merlins, but I did not consider them in the analysis because of their constant presence.

A hunting flight was defined as a flight involving any number of capture attempts at suitable prey (see Buchanan et al. 1988). A capture attempt is an attempt to seize or knock down a specific prey individual during a hunting flight. I determined duration of hunting flights using a watch. In some cases I was unable to measure the exact duration, thus hunting flights were grouped into one minute intervals and comparisons were made using the Kolmogorov-Smirnov two-sample test (Sokal and Rohlf 1981). In many cases small sample sizes precluded statistical analysis.

Incidences of Kleptoparasitism. Kleptoparasitism was observed five times and occurred after 18.5% of all successful hunting flights by Merlins (N = 27). Kleptoparasitism by a Red-tailed Hawk (*Buteo jamaicensis*) and by a Merlin both occurred in mid-air, whereas a Northern Harrier (*Circus cyaneus*) chased a Merlin from its partially consumed prey on the ground in an open field. On two other occasions Merlins dropped their prey when another Merlin began pursuit; in one case the Dunlin was recovered by a Glaucous-winged Gull and in the other case the Dunlin flew to safety. On three occasions Merlins

were observed to knock down or force Dunlins into water without capturing them (i.e., not considered successful hunts); the prey was subsequently taken by another bird. In one case the Dunlin was taken by a Bald Eagle (*Haliaeetus leucocephalus*) and twice by Glaucous-winged Gulls. Bald Eagles twice attempted unsuccessfully to capture Dunlins which had been dropped or forced into water.

Kleptoparasitic Threat and Hunting Behavior. Merlins in western Washington commonly use one of two methods when initiating a hunting flight (Buchanan et al. 1988). The most common technique is a conspicuous high flight, usually followed by stoops at a flock or individual birds. The second technique is a low stealth approach which the Merlin uses to surprise its prey.

The success rate for hunting flights was 21.0% (N = 81) when other raptors were absent and 17.6% (N = 34) when other raptors were present. At Kennedy Creek Delta, where nearly half (N = 62) of the hunting flights were observed, the success rate was much lower when other raptors were present (10.0%; N = 30) than when other raptors were absent (21.9%; N = 32).

Because the conspicuousness of stealth attack flights and high flights appeared to be different I compared the duration and effectiveness of each technique when other raptors were present and absent. For stealth attack flights I found that flights were similarly successful when other raptors were present or absent (19.0% and 14.7%, respectively), the distributions of hunting flight durations were similar (see Fig. 1A), and the number of capture attempts per flight was similar (2.43 [S.D. = 2.55] when raptors present vs. 2.14 [S.D. = 2.42] when raptors absent). For high flights I found that when other raptors were absent the success rate for hunting flights was higher (25.5% vs. 15.4% when other raptors present) and each flight included more capture attempts (5.58 [S.D. = 7.36] when raptors absent vs. 2.78 [S.D. = 2.01] when raptors present). A small sample size resulted in non-significant findings; however, using the Kolmogorov-Smirnov two-sample test, the difference in distributions of flight durations (Fig. 1B) was significant (D = 0.421), as there were more lengthy flights (following the initial high approach) when raptors were absent and more brief flights when raptors were present.

When other raptors were present, all six successful hunting flights lasted <2 min, whereas seven of 17 successful flights lasted between 2 and 8 min when raptors were absent. All five kleptoparasitic incidents occurred after hunting flights lasting <3 min.

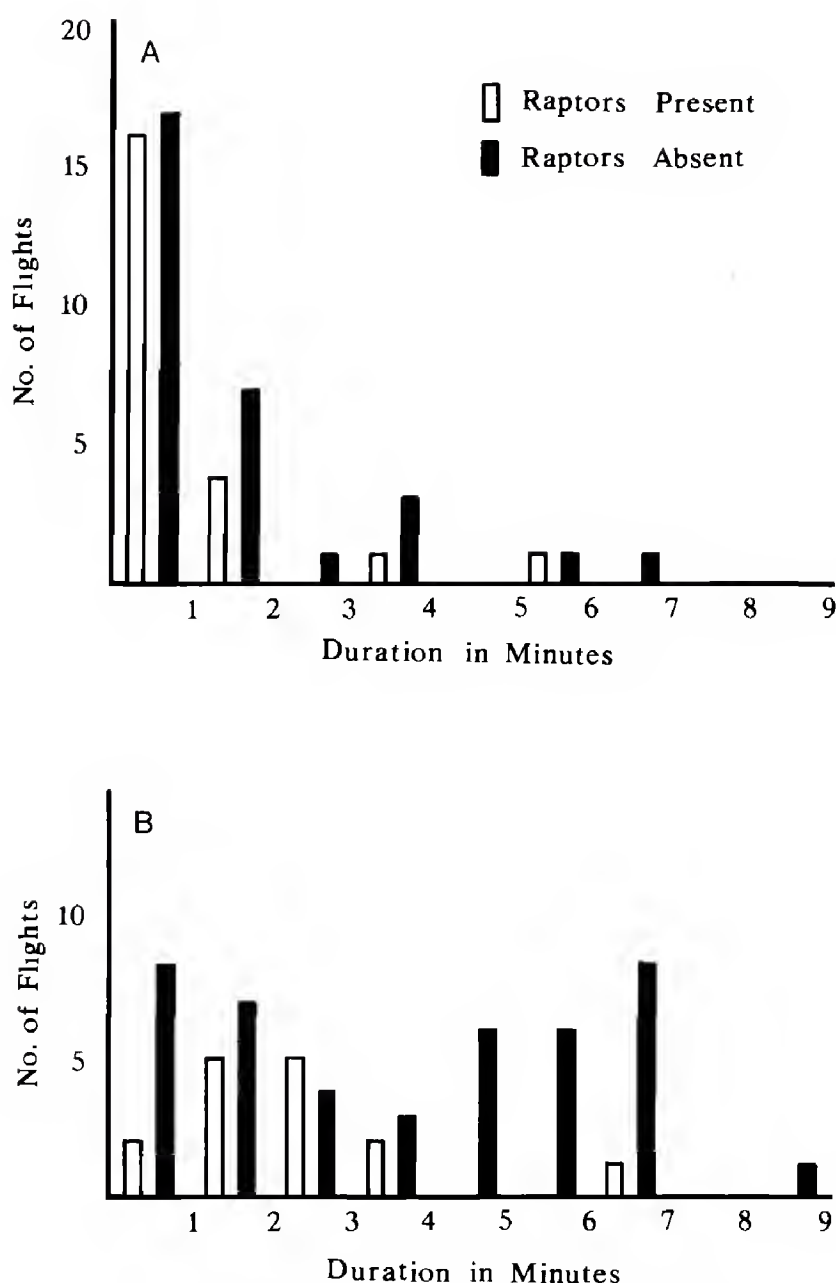


Figure 1. Duration of stealth (A) and high (B) hunting flights by Merlins when other raptors were present or absent.

Discussion. Despite a small sample size, these findings indicate that when raptors are present Merlins hunt effectively by using the low stealth flight, and less effectively by using high flights. Merlins may recognize potential kleptoparasites and attempt to minimize wasted effort by avoiding lengthy and conspicuous hunting flights if the risk of food piracy is high. Hosts in other kleptoparasitic relationships are known to alter their foraging strategy to optimize intake and reduce opportunities for piracy. Barnard and Thompson (1985) found that Northern Lapwings (*Vanellus vanellus*) and Greater Golden-Plovers (*Pluvialis apricaria*) took less profitable (smaller) prey when kleptoparasitic Common Black-headed Gulls (*Larus ridibundus*) were present.

Although the results of this study indicate that kleptoparasitic pressure may depress hunting success, the success rate for hunting flights by Merlins in Washington (22.5%; Buchanan et al. 1988) was significantly higher than reported from California (12.5%; Page and Whitacre

1975). Whether the magnitude of kleptoparasitic pressure is greater in Washington than California is unknown. However, substantial differences exist between the two regions in hunting behavior (foraging polymorphism; see Morse 1980). Regional differences in kleptoparasitic pressure may result in increased foraging polymorphism and differences in success rates. For example, a preponderance of high flights in Washington (Buchanan et al. 1988) may allow Merlins to continuously assess chances of being kleptoparasitized. The impact of kleptoparasitic pressure might therefore be a consideration when making comparisons of hunting behavior.

Prey caching may be a response to kleptoparasitic pressure on host Merlins in western Washington. Winter caching by Merlins has been documented (Pitcher et al. 1979, Warkentin and Oliphant 1985) and was twice suspected during the present study. Food caching should be examined as a response to kleptoparasitism when both are known to occur.

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INCIDENTAL CAPTURE OF A NORTHERN HARRIER (*Circus cyaneus*) IN A MAMMAL TRAP

RALPH D. GODFREY, JR. AND ALAN M. FEDYNICH

On 28 December 1985, an adult-female Northern Harrier (*Circus cyaneus*) was captured in a box-trap (Toma-hawk #108). The trap was set on a stream side trail to capture Raccoons (*Procyon lotor*) preying on ducks caught in banding traps. A Green-winged Teal (*Anas crecca*) carcass was used for bait. We have found no records of harrier captures in live traps of this type.

During the 24 hr prior to the Northern Harrier capture, temp ranged from mid-teens to upper 50s. There had been a full moon the two previous nights. No snow was on the ground.

The Northern Harrier was captured at Caprock Feedlot, approximately 10 km SW of Bovina, Parmer Co., Texas (34°20'N 102°25'W). Available wetland habitat where harriers were observed quartering for prey included feedlot-effluent lagoons and an intermittent stream with pools of permanent water. The location is utilized extensively by wintering waterfowl (Fedynich 1987) and experiences recurrent waterfowl epizootics (Wallace et al. 1986; Fedynich and Godfrey 1988). Consequently, waterfowl carcasses provide an easily accessible source of food for scavengers.

Previous reports have documented harriers opportunistically feeding on both live waterfowl (Schipper et al. 1975; Godfrey and Fedynich 1987) and waterfowl carcasses (Errington and Breckenridge 1936; Blohm et al. 1980). Our observation further documents opportunistic use of carrion as food in the Northern Harrier diet.

Throughout the winter, Northern Harriers commonly were observed quartering for prey. Northern Harriers may be attracted to sites that have large waterfowl concentrations, thereby increasing their chances of preying on waterfowl infected with *Pasturella multocida*. Morbidity and mortality from *P. multocida* has been reported in several endemic scavengers (Rosen and Morse 1958; Zinkl et al. 1977; Taylor and Pence 1981). However, the effects of Northern Harrier scavenging on carcasses infected with *P. multocida* are uncertain and further study is indicated.

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BALD EAGLE NEST ON AN ARTIFICIAL TREE-TOP PLATFORM

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Artificial nesting platforms have been used successfully to manage a variety of raptors (Call 1979; Millsap et al. 1987). Nesting on human-made structures by Bald Eagles (*Haliaeetus leucocephalus*) is "extremely rare" (Olendorff et al. 1980). Postupalsky (1978) reported six nesting attempts on three different structures; an oversize Osprey (*Pandion haliaetus*) platform atop a tree whose top was cut off, a reconstructed eagle nest using a wooden pallet, and a tripod-type platform designed for Ospreys. Grubb (1980) was successful in attracting Bald Eagles to a metal tripod supporting a nest. Here we report on Bald Eagles using a tree-top platform, originally part of an observation blind, as a nesting substrate at Besnard Lake, Saskatchewan (55° 20'N, 106°00'W).

Bortolotti (1982) designed an easily assembled tree-top blind consisting of a 1.2 × 1.2 m plywood platform suspended from chains at the two outside corners and supported by a metal brace against the trunk of a tree. One blind used by eagles was situated 25 m above ground in a white spruce (*Picea glauca*). Bortolotti used this blind to observe eagles at the nest in 1980 and 1982. Canvas covering the blind was removed at the end of both summers, but otherwise the structure was left intact and no alterations were made from the time the blind was first constructed in June 1980. One other platform in a white spruce, constructed in August 1980 but never used for observation, was left intact through the 1987 breeding season but not used by eagles to our knowledge (although the platform was not inspected until 1986).

The nest on top of the platform was constructed in 1986. When inspected on 10 June, the nest was about 18 cm thick and as wide as the plywood base. There was a nest cup with some fresh, wet grass and fresh branches of trembling aspen (*Populus tremuloides*). We do not know if eggs were laid in the nest that year, but no young fledged. Repeated visits to the area showed that at least one adult Bald Eagle occupied the territory. On 13 May 1987 a pair of eagles was found with eggs or newly hatched young at an old nest 100 m from the platform. The platform nest contained two nestling Great Horned Owls (*Bubo virginianus*). When again inspected on 10 July 1987 the tree containing the blind platform had blown down—broken at ground level. Approximately two weeks later the eagle nest with young was also blown down in a storm.

Artificial structures may prove useful in managing a variety of species in areas where there is a shortage of natural nest sites (Millsap et al. 1987). Although this typically applies to open-country raptors (e.g., Schmutz et al. 1984), forest-dwelling species may benefit where

large trees have been removed by fire (Bangs et al. 1982) or selective logging, or where the species of trees do not have large branches or open crowns. One interesting aspect of the construction of the nest on the blind platform was that there was no lack of natural nest sites. One intact Bald Eagle nest was 100 m and another 200 m from the blind. Both nests were in trembling aspens and had been used in recent years.

Artificial nesting platforms may be useful in continuing the occupancy or productivity of a territory. Bald Eagles may continue to occupy a territory even after alteration of the habitat has removed all potential nest trees (Herrick 1932; Broley 1947). In areas where excessive human activity poses a threat, it may be possible to encourage eagles to move to a more secluded area by providing them with artificial nests (Postupalsky 1978).

Artificial nests previously used by eagles were large, cumbersome structures (Postupalsky 1978; Grubb 1980). Bortolotti's (1982) platform has several advantages, primarily in being easy to construct, portable in the field and inexpensive. The platform used by eagles survived seven and a half summers and seven winters. The fact that the structure supported the weight of an observer, heavy snow loads and survived strong winds attests to its durability. Blow down of the tree likely had little to do with the platform; several other trees within a radius of a few dozen meters also appeared to have blown down at the same time. The half-life of natural nests on Besnard Lake is only six yrs (Gerrard et al. 1983).

Our suggestions for modifying the original design of the platform pertain to the plywood base: use thicker material (perhaps 20 mm or more), treat the wood with a preservative, drill holes for drainage and perhaps add a lip around the edge. Adding a few branches to simulate a partial nest may encourage nest building.

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FEEDING RESPONSES BY GYRFALCONS TO BROOD SIZE MANIPULATION

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Studies of food consumption by raptors with natural broods of varying sizes have produced equivocal results. Some workers reported little or no difference in total food consumption/nest among broods of varying sizes (Snyder and Wiley 1976; Newton 1978; Simmons 1986), whereas others found total biomass consumed/brood was greater in larger broods, although not proportional to the number of young (Enderson et al. 1972; Snyder and Snyder 1973; Green 1976; Drent and Daan 1980; Nielsen 1986). From 1984-1986, I examined food habits and feeding behavior of Gyrfalcons (*Falco rusticolus*) in the central Canadian Arctic (Poole 1987; Poole and Boag 1988). In natural broods I found that prey biomass delivered/nest varied directly with the number of chicks. In addition time spent feeding by the brood each day was slightly longer for larger

broods, but the number of feeding events (direct feeding or food delivery [Jenkins 1978]) per day (feeding rate) did not vary with brood size. In an attempt to clarify the reasons for these results I manipulated brood size in two Gyrfalcon nests in 1986 and recorded feeding response of the adults.

Two nests were located on the Kilgavik study area in the central Arctic of the Northwest Territories (68°10'N, 106°15'W). The region is composed of rugged mainland tundra and contains low-arctic flora. A general description of the vegetation, climate and geology of the area is reported elsewhere (Poole and Bromley 1988).

Nests were selected in which the oldest nestlings were the same age, and both nests were considered large enough (4 × 1.5 m ledges) to accommodate additional young. At

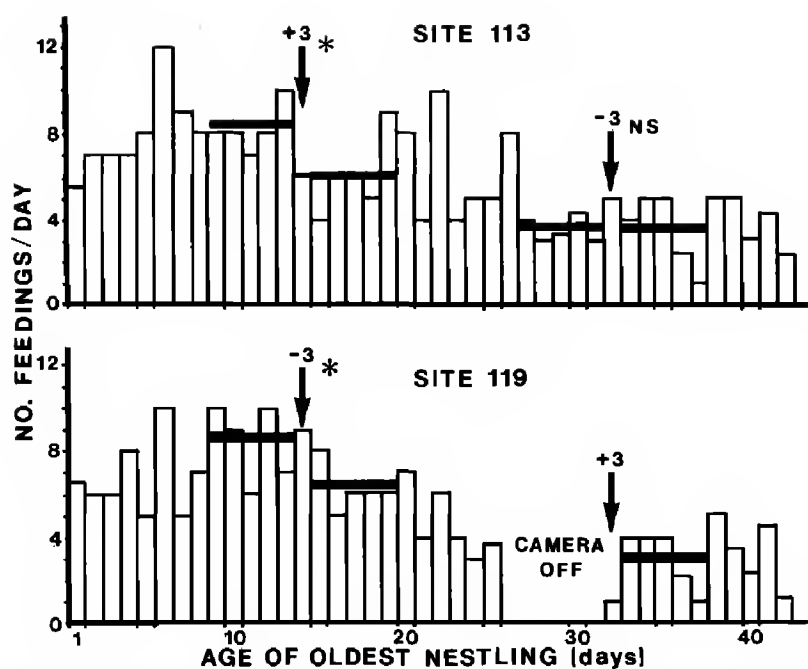


Figure 1. Feeding rate at Sites 113 and 119 during brood size manipulation, Kilgavik, N.W.T., 1986. Arrows denote addition (+3) or removal (-3) of three chicks. Horizontal bars indicate 5-day means before and after manipulation; *t*-test between means, * = $P \leq 0.05$, NS = $P > 0.05$.

Site 113 two female nestlings hatched 1 d apart; at Site 119, 30 km to the east, three females and one male hatched within 3 d.

When the oldest nestlings were 14 d old, one male and two females from Site 119 were moved to Site 113, changing original brood sizes from four to one and two to five, respectively. During the experiment the nests were visited 3 times: at the time broods were initially changed, again when young were 25 d old, and again when young removed from Site 119 were returned to their natal site at 32 d of age.

Time-lapse 8 mm movie cameras (Temple 1972) provided a sampled documentation (three to six min intervals) of activities at the nest, including attendance by adults and frequency and durations of feeding bouts. A period of 5 d before and after both changes in brood size was used for examination of response in feeding rates and total time feeding each day. A 10-d period was chosen for data collection as the best compromise between a period too short to encompass a possible delay in foraging response after manipulation (Snyder and Snyder 1973), yet short enough to fall within similar periods of nestling growth (linear growth occurs between 6–27 d of age [Poole 1987]).

Each site was visited 10 times during the entire nestling period. On each visit prey remains and pellets were collected from the nest, at the base of the nest cliff, and at accessible perches and plucking sites to determine the species and biomass of prey eaten since the previous visit. The minimum number of individuals in each collection was

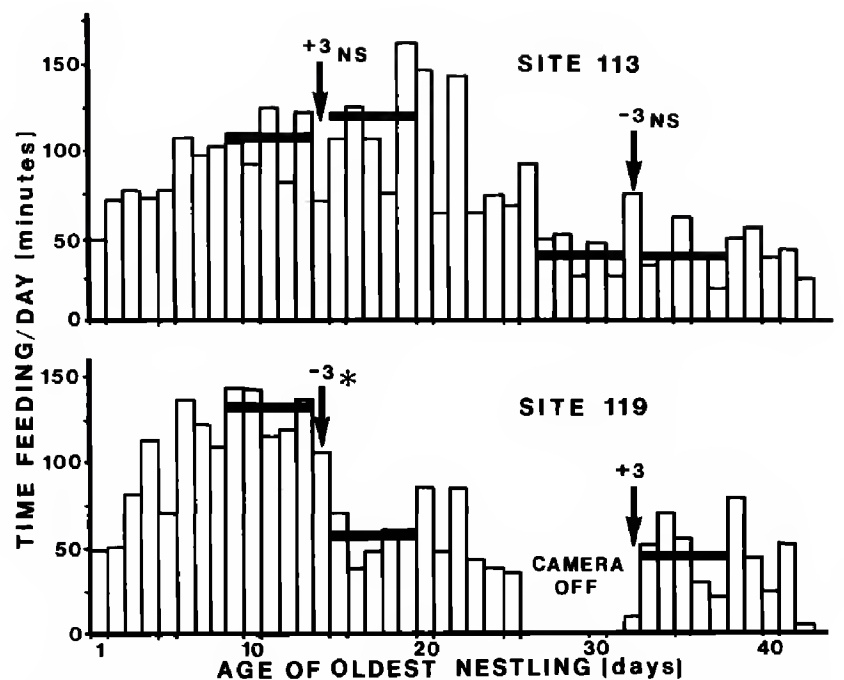


Figure 2. Time feeding/d at Sites 113 and 119 (see Fig. 1 for explanation).

determined by counting the most frequently occurring bone or body part that represented one individual. Mean prey biomass used/d during each period covered by a collection was examined for approximately 1 wk before, during, and one wk after the manipulation experiment, corresponding to timing of prey collections. Weights of chicks were obtained on most (seven to nine) visits.

Following addition of three nestlings to Site 113, feeding rate declined (Fig. 1). The post-manipulative feeding rate was significantly lower (*t*-test, $P = 0.02$) when 5-d pre- and post-manipulation periods were compared. Total post-manipulation time feeding increased slightly, but not significantly ($P > 0.5$; Fig. 2). A similar post-manipulation comparison was not possible at Site 119 because of camera malfunction. Reduction in brood size at Site 119 was followed by a significant decline in both feeding rate ($P = 0.05$; Fig. 1) and total time feeding/d ($P < 0.01$; Fig. 2). No change occurred when nestlings were removed at Site 113 in either feeding rate ($P > 0.5$) or total time feeding ($P > 0.5$).

Mean biomass of prey used/d at each site increased with larger brood size (Table 1; comparing mean biomass (BM) used/d in each period with brood size (BS), combining sites: $BM = 153BS + 525$, $r = 0.98$, $P = 0.001$, $N = 6$). Adult female Gyrfalcons were observed to eat occasionally at nests and perches where prey remains were collected and were counted as one "chick" for calculations. When mean biomass of prey/"chick"/d was calculated, chicks in the larger broods received less on a per capita basis (Table 1; combining sites: $BM = -29BS + 347$, $r = -0.93$, $P < 0.01$, $N = 6$). Mean prey weight increased throughout the nestling period at both sites (Table 1).

No weights of chicks were obtained at Site 113 after original brood size was restored, precluding comparison

Table 1. Mean biomass of prey/d and prey/chick/d, and mean prey weight at Sites 113 and 119, at which brood sizes were experimentally manipulated, Kilgavik, NWT, 1986.

	Site 113		Site 119			
No. chicks	2	5	2	4	1	4
Age of oldest chick (d)	8-14	14-32	32-40	7-14	14-32	32-38
Mean prey biomass/d (g)	803	1269	841	1221	684	1092
Mean prey biomass/"chick"/d (g) ^a	268	212	280	244	342	218
Mean prey weight (g)	438	544	560	389	456	546

^a "Chick" includes nestlings and adult female; see text.

of growth rates with different brood sizes. The most reliable indication of effect of brood size on chick weight is given by comparing weight of the female nestling that stayed alone at Site 119 (Chick A) with the same-age female sibling transferred to Site 113 (Chick B). Chick A was 40-65 g (12-26%) lighter than its sibling during the seven d prior to the initial manipulation. Midway through the manipulations weights of both chicks were virtually identical (5 g difference), and when the original brood sizes were restored Chick A was 185 g (15%) heavier than its sibling, indicating that once alone Chick A grew faster. Chick B's weight increased to within 45 g (3%) of Chick A's weight when final measurements were made 6 d after the last manipulation.

Adult Gyrfalcons at each nest appeared to respond to alterations in brood size by compensatory changes in total prey biomass fed to nestlings and, to a lesser degree, in total time spent feeding nestlings each day. However, feeding rates did not show a similar pattern of response, probably because of inherent biases involved in calculation of feeding rate. For example, five passerines eaten in 1 d would have the same rate as five Rock Ptarmigan (*Lagopus mutus*), but vastly different total time spent feeding and total biomass consumption. Secondly, caching, observed regularly into the fourth week post-hatch (Poole and Boag 1988), would also confound analysis based on rate alone. The same rate could result from one ptarmigan fed to one nestling three times, or a whole ptarmigan fed to a larger brood on each of three occasions. Thus, feeding rate must be used cautiously when prey of greatly differing sizes are taken or are too large to be consumed completely in one feeding. In such cases examination of prey biomass consumed may be more appropriate. The general trend at both nests was an increase then gradual decrease in feeding rate with increasing age of young, a pattern also found at unmanipulated sites (Poole and Boag 1988).

Despite evidence that adults were able to adjust biomass of prey killed, the changes were not in the two to five or four to one ratio expected if adults were responding linearly to the number of young in the nest. According to von Haartman (1954 cited in Drent and Daan 1980), food consumption by each brood is a compromise between nestling demand and the effort required by parents to supply

food. Nestlings in smaller broods in my study received more biomass/d than their counterparts in larger broods, such that in smaller broods nestlings may have been "over-fed" to some degree (Newton 1979). Development of all chicks appeared normal.

Although based on a limited sample, these results suggest that Gyrfalcon pairs were able to adjust prey biomass supplied during the nestling period in response to the number of young.

ACKNOWLEDGMENTS

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- Department of Zoology, University of Alberta, Edmonton, Alberta T6G 2E9, CANADA. Present address: Wildlife Management Division, Northwest Territories Department of Renewable Resources, Yellowknife, N.W.T. X1A 2L9, CANADA.**

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USE OF AN ORAL IMMOBILIZING AGENT TO CAPTURE A HARRIS' HAWK (*Parabuteo unicinctus*)

MICHAEL M. GARNER

A 5 yr old, captive bred Harris' Hawk (*Parabuteo unicinctus*) routinely used for falconry purposes was lost while being flown during a severe thunderstorm in the spring of 1987. The hawk was wearing a single 216 MHz transmitter (Beacon Products, Salt Lake City, Utah) attached to a tail mount. Using a radio receiver (Rb-4 Falconer, Custom Electronics, Urbana, Illinois), the hawk was relocated the following day.

For 6 d the hawk was observed catching and feeding on numerous small rodents. The hawk was also observed robbing several Black-billed Magpie (*Pica pica*) nests of newly hatching nestlings. Due to the abundant availability of prey the hawk refused to return to the falconer when offered food. Several attempts were made to trap the hawk using pigeons (*Columba* sp.) and quail (*Coturnis* sp.) and various Bal-Chartri traps (Berger, D. and Mueller, H., The Bal-Chartri: a trap for the birds of prey. Bird-Banding vol. XXX, January 1959). The hawk cautiously avoided all trapping attempts and would only accept food items from the falconer if left near the perching hawk, or if food was thrown in the hawk's direction.

Previous capture methods being unsuccessful, chemical immobilization was considered as a means of retrieving the hawk. Because of possible impact damage caused by an anesthetic dart, traditional methods of administering an immobilizer were unacceptable. Since the hawk was

indirectly accepting food from the falconer, an alternative was to use an immobilizing agent injected into food that, following ingestion, would act to slow the hawk enough for capture.

Oral immobilizing agents have been used to capture wild birds (Martin, L. L., Comparison of methozymol, Alpha-chloralose and two barbiturates for capturing doves. Proceedings of the 21st. Annual Conference of the Southeastern Association of Game and Fish Commissioners, 1967; William, L. and Philips, R., Capturing Sandhill Cranes with alpha-chloralose. *J. Wildl. Mgmt.* 37(1): 94-97, 1973). Ketamine HCl, however, has apparently not been used as an oral immobilizing agent for capturing birds. Effective oral doses of ketamine HCl are usually 2-3 times higher than Parenteral doses (Fowler, M., Zoo and wild animal medicine, 2nd. ed. W.B. Saunders Company, Philadelphia, PA, 1986), and oral immobilizing agents have previously been rejected as a poor means of restraining wild animals (Fowler 1986).

Ketamine HCl (Ketaset®-Bristol Veterinary Products) at a dosage of 100 mg/kg^a was injected into a 30 gm piece

^a Routine intramuscular dosage for large raptors is 20-30 mg/kg, when not given simultaneously with Xylozine or Diazepam (P. Redig, pers. comm.).

- con in Iceland, with comparative notes on the merlin and the raven. Unpubl. Ph.D. thesis, Cornell Univ., Ithaca, New York.
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of Ring-necked Pheasant (*Phasianus colchius*) breast, and offered to the hawk. After tasting the meat, the hawk shook its head repeatedly but eventually all was consumed. The hawk remained perched on the ground for a brief period, then commenced to soar. One hour following ingestion of the treated food, the hawk showed the first signs of ataxia, having some difficulty remaining steadily perched on a tree limb. The hawk again took flight and soared for several minutes before perching on the top of a tall tree. At this time the immobilizing effects of the ketamine HCl were more obvious, as the hawk spread its wings to balance on the limb and to brace itself amongst the adjoining branches.

Two hours following ingestion of the treated food, the hawk flew from a tree to a ground point 100 m away. The hawk was found in a weakened condition, bobbing its head from side to side. The hawk made no attempt to escape and was recaptured. Three hours following capture the hawk had recovered and showed no signs of having been chemically immobilized. At no point during the immobilization did the hawk lose consciousness.

The oral dose of immobilizing agents in birds has obvious advantages. The procedure described in this case report may be used to recover unresponsive birds used for

falconry or escaped birds involved in research projects. The procedure is an alternative in cases where trapping is ineffective or undesirable. However, chemical immobilization should never be attempted with a non-radiotagged bird. Tracking a treated bird without the advantage of radio telemetry would be nearly impossible. A treated bird that could not be followed would become susceptible to predation or could succumb to unfavorable environmental exposure.

The use of ketamine HCl as an oral immobilizing agent at a dosage of 100 mg/kg was suitable for capture of the Harris' Hawk in this case report. The method should never be used as a means of capturing wild birds due to delayed induction period and other hazards described. Because ketamine HCl cannot be dispensed to the general public, a veterinarian should always be available to supervise administration of the drug and provide supportive care during and after the immobilization period.

Covington Veterinary Hospital, 17414 Southeast 272nd Street, Kent, WA 98042.

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A UNIQUE ENCOUNTER AMONG A GYRFALCON, PEREGRINE FALCON, PRAIRIE FALCON AND AMERICAN KESTREL

THOMAS G. BALGOOYEN

As a consultant for the San Jose International Airport, my duties include trapping and relocating of raptors considered hazardous to air traffic. The airport is located northwest of urban San Jose, California (elevation 25 m).

On 20 November 1986 at 0915 H (PST) with clear skies and temp of 21°C a male American Kestrel (*Falco sparverius*) was caught in a noose carpet set on a low post. A Gyrfalcon (*F. rusticolus*) in juvenile plumage appeared and began a series of shallow dives (15+) at the entangled kestrel. At the same instance a juvenile Peregrine Falcon (*F. peregrinus*) was heard to make several vocalizations ("kaks") from overhead. As the Gyrfalcon departed flying south, the Peregrine feigned an attack on the Gyrfalcon from a safe distance near the south end of the main airport runway. At that time a male Prairie Falcon (*F. mexicanus*) was seen circling overhead and above the two falcons. The Peregrine was struck and killed by an Eastern Airlines DC-10 which was on a landing approach from the south. The pilot relayed the strike to tower personnel who retrieved the dead Peregrine and presented the carcass to

me. The Gyrfalcon was not seen again, but the Prairie Falcon remained overhead.

Morphometric data collected that day on the Peregrine were weight (975 g), wing chord (flattened; 365 mm), tail length (211 mm), total length (572 mm), total wingspan (1114 mm), length of digit III (48 mm; toe only, flattened), standard culmen (6.2 mm); no remex or rectrix feathers were missing. The Peregrine was banded as a 30 d old nestling with a U.S. Fish and Wildlife Service leg band on 16 July 1986 along the Yukon River near Anvik, Alaska (P. Bente, pers. comm.). The carcass was given to the Santa Cruz Predatory Bird Research Group, Santa Cruz, California. On 22, 23 and 24 November 1986 a Gyrfalcon in juvenile plumage was seen at Dixon Landing <5 mi north of San Jose Airport (B. Walton, pers. comm.).

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THE OCCURRENCE OF MELANISM IN AN AMERICAN KESTREL

THOMAS W. CARPENTER AND ARTHUR L. CARPENTER

On 14 May 1986 we captured, banded and released a partially melanistic male American Kestrel, (*Falco sparverius*) (Fig. 1) at Whitefish Point, Chippewa County, Michigan. Plumage differed from normal by having an almost completely black tail, black upper tail coverts, black primary coverts, and black alula. Greater, middle and lesser secondary coverts, marginal coverts, the rump, and the back also had much more black coloration than usual (Fig. 1). The underside (throat, breast, belly, flanks, wing linings) of the bird and the crown were normal in color.

Neither Bent (Life histories of North American birds of prey, part 2. Dover, 1961) nor Gross (*Bird-Banding* 36: 240-242, 1965) reported melanism in the American Kestrel, and a review of the literature from 1965-1986 also failed to reveal any records. We have banded over 250 American Kestrels and have never encountered a similarly

colored bird. David M. Bird (pers. comm.), who has bred over 1000 American Kestrels in captivity and studied over 100 breeding pairs in the wild, has also never encountered a melanistic plumage. However, melanism is known to occur in the European Kestrel, *Falco tinnunculus* (Sage, *Br. Birds* 55:201-225, 1962; Rense, *Limosa* 44:62, 1971).

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3646 S. John Hix, Wayne, MI 48184.

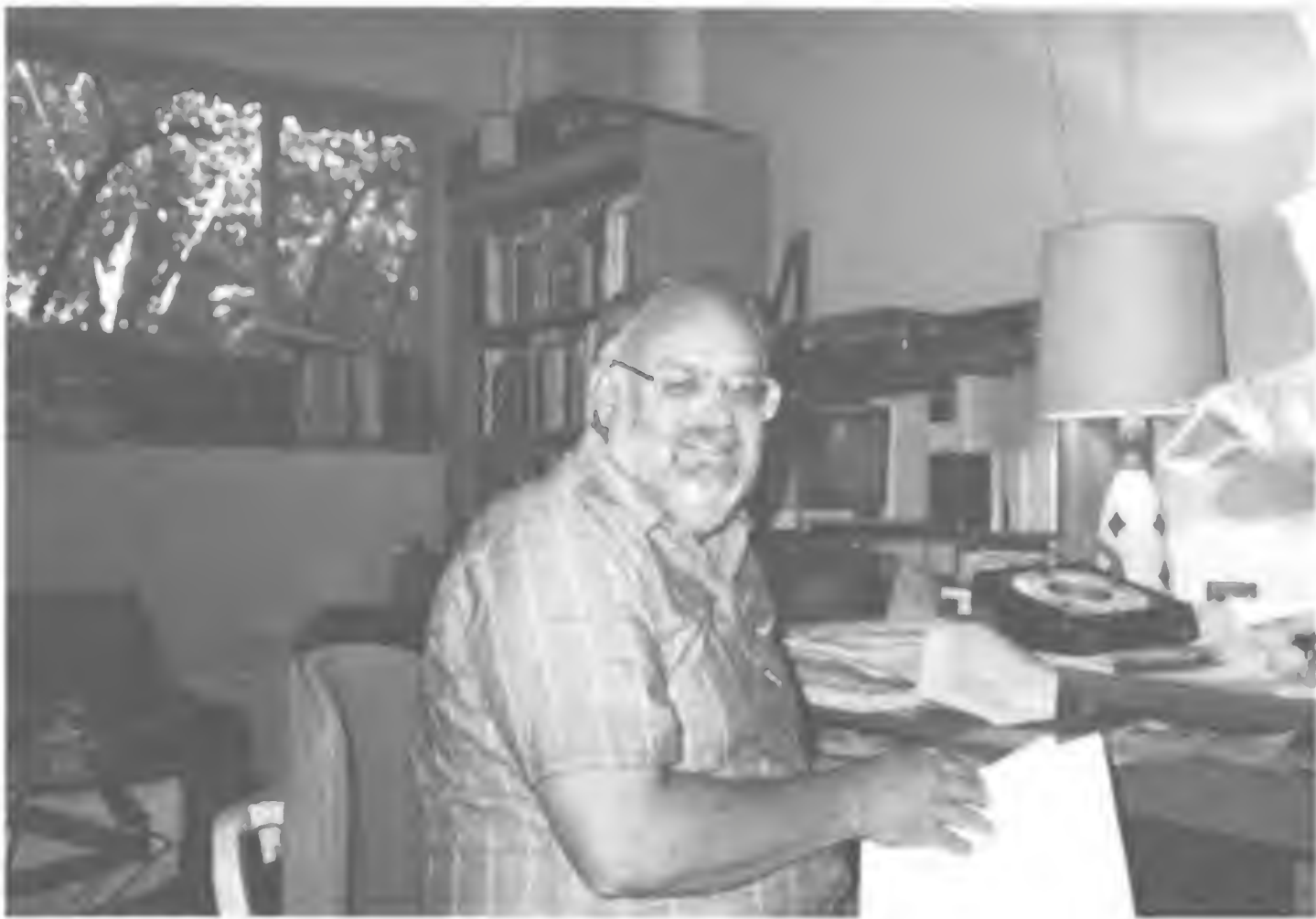
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Figure 1. Partially melanistic American Kestrel captured at Whitefish Point, Michigan.

IN MEMORIAM: JAMES R. KOPLIN

MICHAEL W. COLLOPY



James R. Koplin, a long-standing member of The Raptor Research Foundation, Inc., died on 18 May 1987. Jim Koplin was born in Monte Vista, Colorado on 9 June 1934 and obtained B.S. and M.S. degrees in Wildlife Technology from the University of Montana, Missoula, in 1959 and 1962, respectively. He received his Ph.D. in Zoology from Colorado State University, Fort Collins in 1967. Jim was an Assistant Professor of Biology at the State University of New York at Albany from 1965 to 1967. During the summers of 1966 through 1968, he also served as a Visiting Professor of Zoology at the University of Montana Biological Station at Flathead Lake. In 1967 Jim joined the faculty of the Department of Wildlife Management at Humboldt State University, where he taught and conducted research for the following 20 years. During this time he also served as Director of Graduate Studies of the School of Natural Resources (1970-1974) and Chairman of the Department of Wildlife Management (1974-75 and 1976-77).

Jim Koplin's early research contributions included important papers on competitive exclusion in voles and nu-

merous articles on woodpecker predation. More recently, he made significant contributions to our understanding of the behavioral ecology, nesting biology, energetics, and habitat use of raptors. Those of us who knew and worked with Jim over the years, greatly appreciated his leadership and biological intuition. We also loved him for his company, his wit, and once a year, for his lousy graphics.

Perhaps the most significant contribution Jim Koplin made to the fields of raptor biology and wildlife ecology was in training young professionals. In his 20-plus years as an educator, literally thousands of young scientists took his courses in wildlife ecology, management and population dynamics. As a result of his long-term commitment to training young ecologists, Jim Koplin's contributions will be felt for many years to come. Jim is survived by his wife Phyllis, his mother, one son, two daughters, four brothers, one sister, and seven grandchildren.

Department of Wildlife and Range Sciences, University of Florida, Gainesville, FL 32611.

NEWS AND REVIEWS

Hawks by William S. Clark, illustrations by Brian K. Wheeler. Peterson Field Guides. Houghton Mifflin Company. Boston, 1987. 200 pp. Cost \$13.95 U.S.

Thirty-nine species of North American diurnal raptors are covered in this handy field guide. The species covered include those that the careful and persistent observer would expect to see and, surprisingly, a few very uncommon ones [i.e., Roadside Hawk (*Buteo magnirostris*) White-tailed Eagle (*Haliaeetus albicilla*) and Stellar's Sea Eagle (*H. pelagicus*)]. Despite some misspelled words, and inconsistencies between the text and the Table of Contents, the Introduction does a good job of instructing the reader how to use the guide.

The "Topography of a Hawk" section is complete, quite useful, and can be used with the "Anatomy of a Raptor" on the front endpaper (although it is listed as "Topography of a Hawk" on the *back* endpaper).

Each species is covered in more detail than can be found in any generic bird guide, and addresses: common and scientific name; description; field marks (using the Peterson Identification System of arrows); plumages; reference to similar species; mode of flight; behavior; occasional reference to call; status and distribution; clear, but fairly generalized, range maps; fine points; unusual plumages; a listing of subspecies (all races north of Mexico); etymology; measurements; plates; and photographs. These points are covered nicely and, with the possible exception of range map errors (e.g., for *Buteo swainsoni*; J. Parrish, pers. comm.), appear to be accurate.

The 26 (not 27 as indicated in the Introduction) plates are grouped in the center of the guide which provides ready access to both the artwork, which is of comparable quality to that in the better bird guides, and informative legends on the facing pages. The 42 pages of black and white photographs are variable in quality and usefulness. Some photos are of exceptional clarity, while others are so dark or out of focus as to be of limited value.

The Reference section is particularly impressive, providing both the amateur and professional a useful bibliography. Complementing the Reference is a valuable Index to References by Species and Topic. Topics include: natural history; behavior; plumage; migration; status and distribution; identification; albinism; bibliography; and taxonomy. For quick reference to the "right" species an index is provided. Finally the classic raptor silhouettes are provided on the back endpaper (although it is listed in the Table of Contents as being on the *front* endpaper).

Despite some poor editing, which should be clarified in subsequent editions, the layout and contents of "Hawks" make it a very useful inclusion for anyone's back pocket or field bag. This Peterson guide has accomplished the goal of simplified field identification and is worth the \$13.95 selling price.—**Jeffrey L. Lincer.**

Request for Assistance.—Population status and health of Snowy Owls in North America; request assistance in obtaining field observations and carcasses. Please forward the following information for each sighting: date, location, number of birds seen, age and sex of birds seen, what birds were feeding on, the observer's name, address and telephone number, and any additional information which the observer wishes to supply. Please report sightings to **Ursula C. Petersen, 436 Birge Hall, Department of Zoology, University of Wisconsin, Madison, WI 53706.**

Birds of Prey: An Identification Guide to the Raptors of the World. Book is due for completion in 1988; published by Christopher Helm, Ltd., in the same series as *Seabirds*, *shorebirds* and *waterfowl*. Colour plates (112) will show all birds of prey in all main plumages, perched and in flight. Illustrating the underwings and some other fine details is, however, a problem for certain species where museum skins, published photographs and our field notes are all inadequate. We are, therefore now asking for photographs (particularly showing birds in flight or in the hand) of any of the following:

Afro-Malagasy Cuckoo-hawks (*Aviceda cuculoides* and *A. madagascariensis*);
Honey Buzzards (*Henicopernis longicauda*, *H. infusca* and *Pernis celebensis*);
the African Banded Snake Eagles (*Circaetus fasciolatus* and *C. cinerascens*);
any island (not mainland) species or race of the Asiatic Serpent Eagles (*Spilornis*);

the Afro-Malagasy Serpent Eagles (*Dryotriorchis* and *Eutriorchis*);
 any species of *Accipiter* (in which we include *Erythrotriorchis* and *Megatriorchis*) EXCEPT FOR *tachiro*, *novaehollandiae* (Australian nominate race), *nisus*, *rufiventris*, *striatus*, *bicolor*, *cooperii* and *gentilis*;
 the Old World hawks *Butastur* (all species);
 the African Long-tailed Hawk (*Urotriorchis macrourus*);
 the New World hawks *Leucopternis* (all species) and *Buteogallus subtilis*;
 the two Central and South American Solitary Eagles (*Harpyhaliaetus*);
 the buzzards/hawks *Buteo ridgwayi*, *B. brachypterus*, *B. regalis* (dark adult and juvenile) and *B. auguralis*;
 the Crested Eagle (*Morphnus guianensis*) and the harpy eagles (*Harpia* and *Harpyopsis*);
 the Indian Black Eagle (*Ictinaetus malayensis*);
 Wahlberg's Eagle (*Aquila wahlbergi*);
 Gurney's Eagle (*A. gurneyi*);
 the hawk eagles *Hieraaetus dubius*, *H. kienerii*, *Spizastur melanoleucus*, *Spizaetus africanus*, *S. cirrhatus* (race *floris*), *S. nanus* (race *stresemanni*), *S. tyrannus*, *S. bartelsi* and *S. philippensis*;
 and Isidor's Eagle (*Oroaetus isidori*).

We have tried to keep this list reasonably short, but should like to see any other photographs that show points of special interest. For example, until recently we would have added *Accipiter badius* and *A. brevipes* to the list of accipiters excluded, but it is now clear that some Shikras are more easily confused in the field with Levant Sparrowhawks than previously recognized. All photographs should be sent as soon as possible to **P. J. K. Burton, British Museum (Natural History), Akeman Street, Tring, Hertfordshire HP23 6AP, ENGLAND**. Photographs submitted will be acknowledged and later returned to the individual artists.—**James Ferguson-Lees, Philip Burton, Kim Franklin and David Mead.**

Raptours. Raptor watching tours and workshops. 1988–1989 schedule includes: Trinidad, Cape May, Israel, South Texas, Senegal, Mexico, Panama, Tikal, Whitefish Point, Ecuador and southern Arizona. Tours led by Bill Clark, author of *Hawks*. Many three-day weekends. Write for brochure and schedule to **Raptours, P.O. Box 8008, Silver Spring, MD 20907, or call Barbara Fox at (301) 565-9196.**

Reprints Wanted. Are your raptor reprints taking up too much space and gathering dust? The U.S. Bureau of Land Management would like to add them to the Raptor Management Information System (RMIS) or to its General Raptor Reprint File. In return, you receive an appropriate amount of free use of the computerized systems. For details, write **Richard R. (Butch) Olendorff, U.S. Bureau of Land Management, 2800 Cottage Way, Sacramento, CA 95825, Phone 916-978-4725.** Also, if you are interested just in using the extensive literature retrieval capability of the RMIS, write or call for a free brochure.

Prairie Endangered Species Workshop Proceedings. One-third of all the rare, threatened, and endangered species in Canada were once regular inhabitants of the prairie grasslands. Ploughing of native prairie for agriculture has virtually eliminated the grassland habitat on which these species depend. With this background, a 3 d workshop was held at the Provincial Museum of Alberta, Edmonton in January 1986 by the Federation of Alberta Naturalists. During the 32 sessions, 90 speakers from 30 organizations discussed the conservation and management needs of endangered prairie habitats and wildlife. Proceedings from the workshop are now available.

The Proceedings include 83 papers on endangered habitats and most threatened and endangered wildlife in the three prairie provinces. The papers on habitat confirmed that over 75% of all prairie habitats have been ploughed, grazed or urbanized. Over 95% of mixed grass prairie has been irreparably disturbed. Papers on individual species discussed the status of each species, current management, the need for a recovery plan and future conservation needs. A number of low profile species such as the Bull Trout, Leopard Frog, and a variety of insects and plants were included in an effort to stimulate more conservation activity. To order copies of the proceedings of the Workshop on the Endangered Species in the Prairie Provinces, Occasional Paper No. 9 (1987) of Provincial Museum of Alberta send \$10 U.S. per copy to **Edmonton Natural History Club, Box 1582, Edmonton, Alberta T5J 2N9.**

1989 Hawk Mountain Research Award. The Hawk Mountain Sanctuary Association is accepting applications for its twelfth annual award for raptor research. To apply for the **\$750 award**, a student applicant should submit a brief description of his or her research program (five pages maximum), a *curriculum vitae*, and two letters of recommendation to **Dr. Jim Bednarz, Hawk Mountain Sanctuary Association, Rte. 2, Kempton, PA 19529. The deadline for applications is October 15, 1988.** The Association's board of directors will make a final decision early in 1989. Only students in degree-granting institutions are eligible to apply; both undergraduate and graduate students may apply. The award will be granted on the basis of a project's potential to improve understanding of raptor biology and its ultimate relevance to the conservation of North American raptor populations.

1988 Hawk Mountain Research Award. The Hawk Mountain Sanctuary Association awarded its 1988 research grant to Holly Devaul, a M.S. candidate at the University of Maine. Her project is entitled "Survey of Breeding Woodland Hawks: A Comparison of Forest Mangement Practices."

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